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Population Aging and Sustainability of Pension Funds

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Abstract: In light of the nation's increasingly pressing aging problem, achieving sustainable development of China's pension insurance fund is a key objective of the country's present social security system reform. The first subject addressed in this paper is the connection between aging and the sustainability of the pension insurance fund. An econometric model can be used to illustrate how the aging population will reduce the basic pension insurance fund's balance rate. This will have an additional effect on the fund's income and expenditure balance, causing a payment gap and hindering the fund's capacity to develop sustainably. As such, a review of the national pension insurance program is carried out. From the perspectives of policy concerns and improvement ideas, we argue for the soundness and areas for development in the national pooling policy of pension insurance funds. The sustainability of pension insurance funds is the ultimate goal, and it also helps with the difficulties brought on by shifting demographics and the pressure on pension insurance fund contributions.

Keywords: population aging, basic pension insurance fund sustainability, national coordination.

1. Introduction

Recently, China has been confronted with significant pressures from an aging population. In 2021, the proportion of elderly people aged 60 and above in China will be 18.9%, and the number of elderly people aged 65 and above will be 2005.6 million, which is already far beyond the international social red line of aging. The large changes in China's demographic structure have brought about far-reaching social impacts [1]. That being said, it is crucial to monitor the evolution of China's pension insurance fund. China's urban basic pension insurance fund income saw negative growth in 2020 for the first time in several years in fund revenue and expenses, but it started to grow again in 2021. China's urban workers' pension insurance program is now operating comparatively smoothly overall. The situation is still mostly steady in terms of fund earnings and expenses as well as the accumulated balance, but the pension is going to be under more and more financial strain in the future. It is even tending to ongoing degradation and decline [2].

How to realize the sustainable development of the pension insurance fund in the environment of population aging is the focus of this paper. Aging populations will put pressure on the pension insurance fund's income and expenses, weakening the fund's income growth rate and raising the potential of a dynamic budget gap in the future [3]. The fund's resilience and sustainability will be impacted by the growing pension gap, which is detrimental to the long-term, sustainable growth of

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pension insurance. Therefore, we carry out an empirical analysis to establish a model of the relationship between population aging and the sustainability of the pension insurance fund and use the data to verify the impact of population aging on the sustainability of pension insurance. Based on this relationship, we will study the current policies and recommendations.

2. Literature review

Faced with the topic of population aging and the sustainable development of pension insurance funds, scholars have carried out more research.

Scholars generally realize that the sustainable development of the pension insurance fund faces multiple challenges. Qi Yuliang builds the growth model of the pension insurance fund, takes into account the tax rate and financial subsidy strength of the fund, and investigates the ideal fund size at various phases of population aging development [4]. Wang Yunhong, Wang Xia, and Hu Yifan explored the impact of transferring equity gains to supplement the pension insurance fund on the sustainability of Shandong province's enterprise employee pension insurance system [5]. Fan Wei-Qiang, Liu Junxia, and Yang Huawei explore three modes of adjusting the contribution mode [6]. Yao Jin concentrates on the aspect of lowering the contribution rate for the new policy of lowering the contribution base and rate of return on investment. While Jia Hongbo and Hao Jiaojiao simulate the various policy combinations in the scenario of "mixed account" management, Liu Shufeng and Gao Shuo develop the actuarial model of the income of the basic pension account for urban workers. Gao Chengyu and Li Peng create the actuarial model of the fund's coordinated account and individual account. These four academic groups examine how this policy affects the long-term viability of the fund [7][8][9][10].

Further, scholars have also conducted research from different perspectives on the specific background factors of population aging. Fan Wei-Qiang, Liu Junxia, and Yang Hualei focus on the impact of different fertility levels on the financial status of pensions, emphasizing that the adjustment of fertility policy should be matched with the adjustment of the pension system [11]. Wei Chenxue, Li Xiaolin, and Zeng Yi examine how delaying the retirement age will affect urban workers' basic pension funds [12]. And Liu Wei, Liu Changping measured from the aspect of the United Nations 2016-2100 China's population projection data, combined with the factors of population mobility, urbanization, and aging [13].

Overall, the literature now in publication examines a variety of issues, including population aging, that have an impact on pension fund sustainability. However, more work has to be done to address the fundamental connection between pension funds and population aging.

3. Mechanism analysis

The number of retirees receiving pensions rises in tandem with the population's progressive increase in the proportion of older people. The Pension Insurance Fund now needs to pay higher pensions to cover the living expenses of the elderly as a direct result of this increase in spending requirements. Conversely, the fund's source of contributions has shrunk as a result of the proportionate decline in labor supply. This discrepancy between income and expenses will have a substantial effect on the pension insurance fund's accumulation, jeopardizing the fund's long-term sustainability. Drawing from the aforementioned analysis, this work advances the following theoretical suppositions:

Scenario 1: An obstacle to the Pension Fund's sustainability is the aging population, which puts more strain on the Fund's spending and decreases fund accumulation.

The working-age population will decline proportionately as the population ages, which will have an immediate impact on the pension fund's contribution base. As the proportion of the contributing population declines, the Fund's revenue streams become more limited, and meeting the growing

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demand for pension payments may prove difficult. The government may think about raising the contribution rate to keep the pension fund's revenue and expense ratios in balance. The financial burden of individual and business contributions will rise as a result. Drawing from the aforementioned analysis, this work advances the following theoretical suppositions:

Scenario 2: The sustainability of pension funds is impacted by population aging, which lowers the share of the population making contributions and raises the cost of those contributions.

Stricter requirements are now necessary for the pension insurance program to continue to be viable as the population ages. To address this difficulty, the government must constantly enhance the pension insurance system's architecture. Some examples of these improvements include enhancing national coordination, modifying the contribution rate, streamlining the pension payout process, and broadening the fund's investment channels [14]. To preserve the fund's balance, the government could also need to take on more accountability for financial support. This may hinder the advancement of other social projects and put more financial strain on the government. Drawing from the aforementioned analysis, this work advances the following theoretical suppositions:

Scenario 3: As a result of systemic effects and increased fiscal pressure, population aging poses a threat to the pension fund's sustainability.

4. Data description and modeling

4.1. Model Setting and Variable Selection

To test the related theoretical research hypotheses, this paper builds the following inter-provincial panel data model of population aging affecting the sustainability of the basic pension insurance fund and simultaneously employs the least-squares method for estimation. The previous paper examined the impact of population aging on the basic pension insurance fund.

$$Fund_{it} = \beta_0 + \beta_1 \times Aging_{it} + \beta_2 \times Eco_{it} + \beta_3 \times Inc_{it} + \beta_4 \times Uis_{it} + \beta_5 \times Edu_{it} + \beta_6 \times Tra_{it} + \varepsilon_{it} \quad (1)$$

Considering individual fixed effects, an econometric model can be built to test the impact of population aging on the sustainability of the basic pension insurance fund.

$$Fund_{it} = \beta_0 + \beta_1 \times Aging_{it} + \beta_2 \times Eco_{it} + \beta_3 \times Inc_{it} + \beta_4 \times Uis_{it} + \beta_5 \times Edu_{it} + \beta_6 \times Tra_{it} + \lambda_{it} + \varepsilon_{it} \quad (2)$$

In parallel, the following econometric model is developed in this study to investigate the impact of population aging on the basic pension insurance fund's sustainability.

$$Fund_{sp_{it}} = \beta_0 + \beta_1 \times Aging_{it} + \beta_2 \times Eco_{it} + \beta_3 \times Inc_{it} + \beta_4 \times Uis_{it} + \beta_5 \times Edu_{it} + \beta_6 \times Tra_{it} + \varepsilon_{it} \quad (3)$$

Where i denotes province; t denotes period; the explanatory variable Fund represents the regional urban basic pension insurance fund balance rate, and Fund_sp represents the rate of change in the regional urban basic pension insurance fund balance, and Fund_sp is calculated as ($Fund\_sp_{it}$-$Fund\_sp_{it}$-1)/$Fund\_sp_{it}$-1; the core explanatory variable Aging represents the regional elderly population dependency ratio; ε_{it} is a random disturbance term; and λ_i represents individual fixed effects. To control the effects of other variables, control variables are selected. These include ① the regional GDP growth rate, which expresses the level of economic growth (Eco); ② the growth rate of disposable income per capita, which expresses the level of residents' income (Inc); ③ the industrial structure, which is measured by the increase in the proportion of tertiary industry in each province's regional GDP (Uis); ④ the share of each province's general budget expenditure on

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education(Edu); ⑤ the level of infrastructure, which is determined by the share of fiscal transportation expenditures in each province's general budget expenditures (Tra).

4.2. Description of data sources

This research employs panel data from 31 province administrative units across China from 2010 to 2022 as the sample due to certain missing data in Tibet. The China Statistical Yearbook, the China Population and Employment Statistics Yearbook, and the statistical yearbooks of other regions are the sources of the data used.

5. Variable description and empirical analysis

5.1. Descriptive statistics

Table 1 makes it clear that the basic pension insurance fund balance rate has a low standard deviation, which suggests that the fund's revenue and costs are dispersed more equally among the provinces. Additionally, the fund's income and expenses are comparable across regions, with the smallest value being -0.392, indicating that the fund's income has not been sufficient to cover expenses in certain districts and cities.

Table 1: Descriptive statistics of relevant variables

variant	observed value	average value	(statistics) standard deviation	minimum value	maximum values
Fund	403	0.988	0.511	-0.392	3.198
Aging	403	0.151	0.046	0.067	0.288
Eco	403	1.067	0.053	0.704	1.172
Inc	403	-0.011	0.079	-0.311	0.433
Uis	403	3.882	0.175	3.480	4.436
Edu	403	0.162	0.027	0.099	0.222
Tra	403	0.065	0.026	0.023	0.172

5.2. Model results and analysis

In this paper, the sample data were analyzed by random effect and fixed effect models, and the Hausman test results of model (1) had a P-value of 0.0006 less than 0.06, so the fixed effect model was finally chosen to present the results.

The basic pension insurance fund balance rate and the population aging rate are significantly correlated, with a correlation coefficient of -1.907. The population aging regression model on the basic pension insurance fund balance rate is shown in Table 2, Column 1. The growth in income from the pension insurance fund, which helps to fill the revenue gap brought on by increased spending on infrastructure and education, is another factor that affects the sustainability of China's basic pension insurance when all control variables are taken into account. The regression results show that the industrial structure, infrastructure, and educational attainment have a major influence on the basic pension fund balance rate. The population aging regression model with individual fixed effects is displayed in Table 2, Column 2. It has to do with the pension insurance fund's basic balance rate. With a correlation coefficient of -1.914, the findings demonstrate a substantial inverse association between the rate of change in the basic pension insurance fund balance and the rate of population aging. Table 2, Column 3 shows the regression model of the rate of change in the basic pension insurance fund balance due to population aging. With a correlation coefficient of -1.110, the findings

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demonstrate a substantial inverse association between the rate of change in the basic pension insurance fund balance and the rate of population aging. The control variables Uis and Edu have a greater impact on the basic pension insurance fund balance (Fund_sp).

Table 2: Analysis of the results of the impact of population aging on the sustainability of the basic pension insurance fund

VARIABLES	(1) Fund	(2) Fund	(3) Fund_sp
Aging	-1.907***	-1.914***	-1.110***
	-0.671	(0.700)	(0.390)
Eco	-0.0334	0.131	0.951***
	-0.409	(0.409)	(0.327)
Inc	-0.288	-0.235	-0.279
	-0.204	(0.201)	(0.182)
Uis	-0.362**	-0.0396	0.259***
	-0.182	(0.192)	(0.0906)
Edu	2.712***	-0.445	0.922*
	-1.052	(1.104)	(0.530)
Tra	2.584***	-0.909	0.416
	-0.772	(0.773)	(0.569)
Constant	2.107**	0.544	-1.918***
	-0.948	(0.972)	(0.578)
Observations	403	403	403
Number of ProvinceID	31	31	31
R-squared		0.119	

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

5.3. Robustness Tests

This paper decides to test the robustness of the correlation by substituting the explanatory variable indicators, correcting the sample intervals, validating the lagged core explanatory variables, using cross-sectional data, adding supplemental variables, and so on. It is still unclear if the results will remain robust when specific conditions are changed.

Firstly, the fundamental pension insurance sustainability indicator is replaced in this study by the urban pension insurance fund reliance ratio (Fund_Rat). The test results are shown in Table 3 below, column 1:

Table 3: Robustness estimation results of population aging on the dependency ratio of the basic pension insurance fund

VARIABLES	(1) Fund_Rat	(2) Fund	(3) Fund	(4) Fund	(5) Fund	(6) Fund
Aging	-0.109**	-1.568*			-1.907***	-1.867***
	(0.0545)	(0.920)			(0.671)	(0.710)
L. Aging			-2.311***			

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Table 3: (continued).

			(0.722)			
l2_Aging				-2.777***		
				(0.772)		
Eco	-0.0473	2.178*	-0.0299	-0.0222	-0.0334	-0.0334
	(0.0450)	(1.244)	(0.412)	(0.394)	(0.409)	(0.409)
Inc	0.00699	0.283	-0.176	-0.432	-0.288	-0.288
	(0.0250)	(0.448)	(0.254)	(0.324)	(0.204)	(0.204)
Uis	0.00486	-0.511*	-0.374*	-0.519**	-0.362**	-0.362**
	(0.0127)	(0.262)	(0.192)	(0.203)	(0.182)	(0.182)
Edu	-0.00884	0.345	2.472**	1.136	2.712***	2.712***
	(0.0744)	(1.337)	(1.147)	(1.211)	(1.052)	(1.052)
Tra	-0.0781	3.288***	2.672***	2.202**	2.584***	2.584***
	(0.0790)	(0.898)	(0.867)	(0.898)	(0.772)	(0.772)
Constant	0.144*	0.599	2.229**	3.090***	2.107**	2.107**
	(0.0806)	(2.032)	(1.033)	(1.098)	(0.948)	(0.948)
Observations	403	248	372	341	403	403
Number of ProvinceID	31	31	31	31	31	31

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

The results show the same significant inverse relationship between the fund reliance ratio and the dependency ratio of the senior population, with a correlation coefficient of -0.109. This suggests that the aging of the population is a significant factor affecting the financing deficit as well as the relative rate of the dependence ratio.

Second, China provided comprehensive data statistics and introduced the concept of social pension insurance for both urban and rural citizens only in 2012. In 2020, China also extended a statewide 2- to 5-month pension insurance reduction period to firms and individual business households due to the epidemic's adverse economic impacts. This action played a significant role in the basic pension insurance fund's income decline that year [15]. For these reasons, we select 2012-2019 as the sample interval by excluding the sample data of 2010-2011, and 2020-2022 and doing an in-depth robustness test on the above analysis.

The outcomes are displayed in Table 3 above Column 2. After removing special years, the one-way model shows a significant negative link (correlation coefficient of -1.568) between the senior population dependency ratio and the basic pension insurance fund's balance rate. This implies that the explanatory variables in the relationship between the balance rate of the basic pension insurance fund and the dependency ratio of the elderly population are significant factors and that the aging rate will negatively impact the fund's revenue and expenses regardless of whether businesses are exempt from contributing to the fund.

Third, research is required to determine whether there is a lagged negative correlation between the dependency ratio of the elderly population and the balance rate of the basic pension insurance fund. Therefore, the lag 1 and lag 2 old population dependency ratios serve as the main explanatory elements for the basic pension insurance fund balance rate in this article. This research ultimately selects the fixed effect model to perform the lagging test based on the Hausman test findings; the test results are displayed in Table 3's columns 3 and 4.

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Even after trailing the primary explanatory variable by one and two periods, there is still a substantial negative correlation between the basic pension insurance fund balance rate (Fund) and the older population dependence ratio (Aging). According to this, an increase in the old population may have an impact on the basic pension insurance fund deficit growth not only for the current year but also for the next two years. This implies that the basic pension fund gap will rise as a result of the aging population, not just this year but also in the next year or two. The old population dependency ratio is one of the more reliable variables among them.

Fourth, further study employing the cross-sectional data is required to ascertain whether the old population dependency ratio and the basic pension insurance fund balance rate continue to show a substantial correlation in the data from that particular year. In the previous section, it was found that the sudden epidemic in 2020 does not change the correlation between the two variables, so this paper uses the 2020 data as the basis of cross-sectional data analysis. The test results are shown in column 5 of Table 3.

Using cross-sectional data from 31 provinces in 2020, the correlation between the explanatory variables and the explanatory variables is as follows: the balance rate of the basic pension insurance fund (Fund) and the dependency ratio of the elderly population (Aging) continue to have a significant negative relationship. This suggests that, based on 2020 data, the greater the difference between the fund's expenditure and income, the more advanced a province is in its aging process. The aging ratio in the cross-section model remains robust because a higher province's aging rate corresponds with a smaller number of people contributing to the basic pension insurance fund and a larger number of people receiving basic pensions. This causes the gap between the fund's income and expenses to widen.

Fifthly, to conduct robustness tests and to increase the comprehensiveness and explanatory power of the model, it was considered to add an omitted variable to the existing model. The level of Social Security spending (Soc) is therefore chosen. The government's investment in social security, which includes pension insurance, is reflected in the amount of social security expenditures. The income and expenses of the pension fund could be directly impacted by this investment, which would then affect the fund's balance rate. Furthermore, the amount of money spent on social security may vary depending on several factors, including the rate of economic growth, the aging of the population, and the income level of the populace, among others. As a result, using it as a control variable in the model allows for additional testing of the model's resilience. The test results are shown in column 6 of Table 3.

The correlation between the explanatory variables and the explained variables, after accounting for the social security expenditure level variable, is as follows: the basic pension insurance fund balance rate (Fund) and the elderly population dependency ratio (Aging) continue to have a significant negative relationship. In summary, the cross-sectional model's aging ratio is still strong.

5.4. Mechanism testing

The previous section shows that population aging affects fund sustainability through three main mechanisms: fund expenditure pressure, contributing population ratio, and fiscal pressure. This paper tests the influence mechanisms through regression.

In terms of fund expenditure pressure, the urban and rural basic pension insurance fund balance rate (Rur) is chosen as the mechanism variable. Table 4, column 1 shows the results of the mechanism test based on the dependency ratio of the elderly population. Since the Sobel test Z-values are all significant at the 0.05 level, this empirical result indicates that there is a mediation effect. Second, in terms of the proportion of contributing population, the fund collection rate (Coll) is used as the mechanism variable, and the ratio of the actual number of urban and rural recipients to the number of urban and rural insured persons is used to measure the actual degree of receiving pension insurance

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fund in each region. The test findings in column 2 of Table 4 demonstrate that the fund collection rate increases by 0.575 percentage points for every percentage point increase in the older population's reliance ratio. This relationship is significant at the 1% significance level. Third, the mechanism variable for fiscal pressure is the pension fund contribution rate (Con), which is the ratio of urban contributions to the overall salary bill. At the 1% significance level, the correlation value of 0.553 indicates significance. The preceding section's three hypotheses—hypothesis 1, hypothesis 2, and hypothesis 3—are confirmed.

Table 4: Mechanism analysis results

VARIABLES	(1) Rur	(2) Coll	(1) Con
Aging	0.895**	0.575***	0.553***
	(0.441)	(0.142)	(0.159)
Eco	-0.104	0.189**	-0.0648
	(0.323)	(0.0867)	(0.104)
Inc	-0.0305	-0.120***	0.0460
	(0.172)	(0.0432)	(0.0528)
Uis	-4.356***	0.0180	0.00867
	(0.110)	(0.0387)	(0.0420)
Edu	1.201*	-0.000729	-1.292***
	(0.643)	(0.224)	(0.245)
Tra	258.4***	-0.0817	-0.901***
	(0.593)	(0.164)	(0.194)
Constant	16.72***	-0.0506	0.544**
	(0.644)	(0.201)	(0.228)
Observations	403	403	403
Number of ProvinceID	31	31	31

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

6. Conclusion

Keeping in mind the points raised in the previous section about the impact of aging populations on the sustainability of the pension insurance fund, the current course of action to improve China's shortfall in the pension insurance fund in the context of population aging should be to promote national coordination of pension insurance.

First, the rule of law policy offers guarantees in terms of policy reforms. To reconcile current policies regarding individual account contribution rates, pension calculation methodologies, and the participation and contribution of self-employed businessmen and flexibly employed persons, the Social Insurance Law has been further changed. Multi-channel improvement measures are the second. Enhance the online processing of business, enhance the nationally unified public service platform for social insurance, and collaborate to establish a system for reliably administering basic pension insurance funds. Reduce the economic disparities across regions by using regional integration. It also clarifies the roles and responsibilities of local and federal governments and enumerates their financial and administrative rights. In the end, assess the program's efficacy. To quickly address the main issues raised throughout the reform process, the issue of insufficient management, supervision, and

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information systems should be addressed. Big data should be used to enhance management and supervisory systems.

This will help to achieve the scale effect of the basic pension insurance fund, balance regional variations, and effectively alleviate the pension insurance system's sustainable development. Additionally, it will boost the fund's risk tolerance and aid in the preservation and appreciation of its value.

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