Empirical Analysis of Interprovincial Differences in Population Mobility and Pension Fund Balance

-Based on China's Panel Data

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Abstract. Pension systems are essential for smoothing individual lifetime income, while population mobility influences the running of pension systems. Using 2002-2022 China's panel data, this paper constructs double fixed effects models to analyze the interprovincial differences in the impacts of population mobility on pension fund balance. The results show that, interprovincial differences in population mobility and pension fund balances are significant and become more prominent over time. Population mobility has negative effects on the pension fund balance, and the impact sensitivity varies among provinces. Due to population mobility and the pension system chosen to participate in, the effects are strong in some provinces and weak or insignificant in others.

Keywords: Population mobility, Pension fund balance, Interprovincial difference

1 Introduction

Due to population aging and unbalanced regional development, for China's provincial pooled pension systems (That is, a pension system runs within a province), the revenue and expenditure of provincial pension funds gradually fall into a status of imbalance. China's public pension systems include the Pension System for Residents (PSR) and the Pension System for Urban Employees (PSUE), and we study the latter. In 2019, among 15 provinces in which final statements of pension funds were available, only three provinces could keep balanced (Zeng and Yang, 2021) [1]. Comparing household and resident populations from 2002 to 2022, the rate of population outflow from central and western provinces (here, provinces include provinces, municipalities, and autonomous regions) reached a maximum of 17%, while population inflow into fewer eastern provinces reached a maximum of 70%. On 22 February 2022, China's Ministry of Human Resources and Social Security (CMHRSS) announced the start of national pooling (i.e., to plan the running of a pension system from the range of a nation instead of a province) of the PSUE, so as to transfer pension funds nationwide to keep provincial

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balance and ensure full pension payment on time, solving the issue of interprovincial imbalance of pension funds institutionally. However, interprovincial differences hinder the expansion of the PSUE from provincial to national coverage.

The related researches mainly can be divided into two categories: the first is factors affecting pension systems. In a given area, a pension system is influenced by local demographic, social, and economic factors (Chen et al., 2022[2]; Yang and Li, 2023[3]). The second is regional differences in population mobility and pension systems. The mobile population contributes differently to the pension systems in the places of population inflow and outflow (Casarico and Devillanova, 2008) [4]. In the USA, state governments have incentives to compete for the mobile tax bases related to population mobility and adopt diverse pension reform policies (Hoang, 2022) [5]. Population inflow benefits pension systems by improving population quality (Zhang and Zhang, 2024) [6].

Focusing on the influencing factors and regional changes in pension contributions, the existing literature is important to understand pension system differences, but a majority of them are about regional rather than national. The possible contributions of this paper include: from the perspective of national pooling, the authors analyze the interprovincial differences in the effects of population mobility on the pension fund balance; construct double fixed effects models to compare provincial impacts by combining multi-dimensions of population, pension institution, and economy.

2 Theoretical Analysis and Research Hypothesis

To simplify the analysis, based on the two-period Overlapping Generation (OLG) model, we divide an individual's lifetime into two periods of young and old, and denote the current period as *t*. In a given region, in period *t*, household population P_t consists of the elderly population O_t and young labor population L_t. Noting the population mobility rate as π, we assume that the mobile population are labor population with the quantity of πP_t. After mobile, the resident population P_t' and residual labor population L_t' are shown as equations (1) and (2), respectively:

$$P_t' = (1-\pi)P_t \tag{1}$$

$$L_t' = L_t - \pi P_t \tag{2}$$

Under the Pay-As-You-Go (PAYG) finance model, the pension fund expenditure E_t in period *t* depends on the retired population O_t, the average wage in the previous period W_{t-1}, the pension system substitution rate (the proportion of pension to revenue per capita) *s*, and the pension system participation rate *n*, as Equation (3):

$$E_t = snO_tW_{t-1} \tag{3}$$

Assuming that the mobile population participates in the pension system in the place inflow, the pension fund revenue I_t in the period *t* depends on the pension contribution rate *r*, the average wage W_t, and the number of persons covered by the pension system in the workplace $n(P_t' - O_t)$, seeing Equation (4):

$$I_t = rW_t n(P_t' - O_t) \tag{4}$$

The security level of a pension system can be reflected by the pension fund balance. We use the ratio of revenue to expenditure of the pension fund A_t for calculation, reflecting the sustainability of pension fund revenue supporting expenditure:

$$A_t = \frac{I_t}{E_t} = \frac{rW_t}{sW_{t-1}}\left(\frac{1-\pi}{f_t} - 1\right) \tag{5}$$

Where f_t refers to the degree of aging, $f_t = O_t/P_t$. We derive Equation (5) by π:

$$\frac{\partial A_t}{\partial \pi} = -\frac{rW_t}{sf_t W_{t-1}} \tag{6}$$

By Equation (6), the partial effect of population mobility on the ratio of revenue to expenditure of the pension fund is less than 0. It is related to the economic impacts of population mobility (Fenge and Von Weizsäcker, 2010[7]; Adda and Dustmann, 2023[8]) and pension systems (Ma and Hou, 2014[9]; Pang et al., 2016[10]).

So, we propose a hypothesis: the impact of population mobility on the pension fund balance is negative, and due to inconsistencies in demographic structure, pension systems, and economy, the impact sensitivity is not the same among provinces.

3 Research Design

3.1 Econometrically Modelling

A panel data model can effectively solve the endogeneity problem caused by the omitted variables due to unobserved individual (or time) heterogeneities. We construct double fixed effects models:

$$A_{i,t} = \beta_0 + \beta_1 Plr_{i,t} + \gamma Control_{i,t} + \mu_i + \tau_t + \varepsilon_{i,t} \tag{7}$$

$$A_{i,t} = \beta_0 + \sum_{i=1}^{31} \beta_{1i} Plr_{i,t} * N_i + \gamma Control_{i,t} + \mu_i + \tau_t + \varepsilon_{i,t} \tag{8}$$

Where subscripts *i* and *t* denote the province *i* and year *t*, and the explained variable $A_{i,t}$ denotes the pension fund balance. The explanatory variable $Plr_{i,t}$ represents the population mobility rate, $Control_{i,t}$ is a control variable vector, μ_i and τ_t are province and time fixed effects respectively, and $\varepsilon_{i,t}$ is a random error term. N_i is a provincial indicator variable, and N_i=1 corresponds to the province *i*, otherwise N_i=0. Models (7) and (8) are constructed to test the impact of population mobility on the pension fund balance. Model (7) is based on the national sense, with coefficient β_1 indicating the average effect. The changeable coefficient model (8) is based on the regional sense, using the interaction term of N_i and $Plr_{i,t}$, with coefficient β_{1i} indicating the regional effect. Comparing coefficients in the two models, we can obtain the deviation of provincial effects from the average effect, reflecting the provincial differences in the impacts of population mobility on the pension fund balance.

3.2 Definition of Variables

The variables are defined in Table 1. (i)Explained variable: pension fund balance, expressed by the ratio of revenue to expenditure of the pension fund A. Relatively it takes into account both revenue and expenditure of the PSUE. (ii)Core explanatory variable: population mobility rate Plr. When $Plr > 0$, there is a population outflow from the province, and vice versa. (iii)Control variables: to improve the accuracy and reliability of the results and reflect the actual situation more comprehensively, we include 10 control variables about multi-dimensions of population, pension institution, and economy.

Table 1. Variables and definitions

Variable	Symbol	Unit	Definition
Pension fund balance	*A*	1	Ratio of revenue to expenditure of the pension fund
Population mobility Rate	*Plr*	%	(Household population-resident population) /household population
Population aging	*Fold*	%	Proportion of elderly to the total population
Rural population	*Popu_rural*	100 million persons	Population in rural areas
Family household size	*Averscole*	Persons/household	Average quantity of persons per household
Number of retirees	*Numer_re*	Million persons	Quantity of urban retirees covered by the PSUE
Number of the insured persons	*Numer_pen*	Million persons	Quantity of urban workers enrolled in the PSUE
General public budget expenditure	*Budgetex*	10 billion Yuan	Budgeted local fiscal expenditure
Technical level	*Tech*	Item	Quantity of invention patents
Expenditure on education	*Educ_inc*	100 million Yuan	Local government expenditure on education
Number of enterprises	*Enterprise*	10000 units	Quantity of industrial enterprises above designated size
Urban-rural income gap	*Poor*	1	Ratio of personal disposable incomes between urban and rural areas

3.3 Sample Selection and Data Sources

This paper selects a sample of 651 observations, which are 2002-2022 provincial panel data from the Statistics Database of China Economic Network (SDCEN) and the China National Bureau of Statistics (CNBS).

3.4 Basic Analysis

Interprovincial Differences in Population Mobility.

The provincial population mobility rates are shown in Fig. 1. From 2002 to 2022, in a majority of provinces, the population mobility rates exceeded 0, indicating population outflow. But in several provinces, population mobility rates were less than 0, meaning population inflow. Additionally, the inflow rate (i.e., inflow population/ total population) was more extensive. All these suggest that the trend of population mobility was to flow from many provinces to fewer developed provinces. The average population mobility rate (represented by the thin dashed line in Fig. 1) remained constant. Still, in inflowing provinces, the proportion of the inflow population kept growing, and the interprovincial differences in population mobility had expanded.

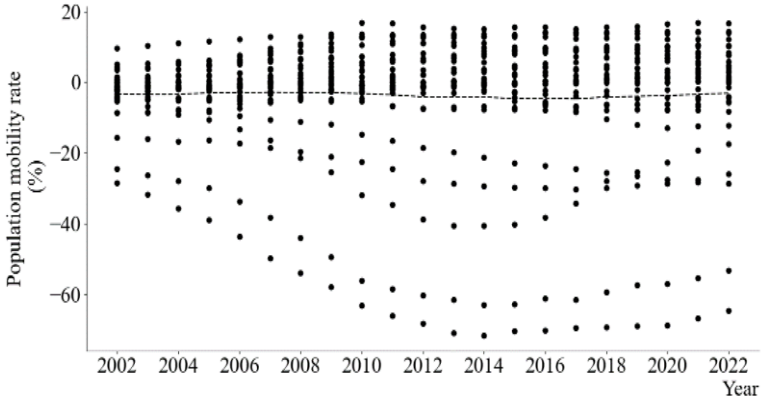

Fig. 1. Trends in the provincial population mobility rate
Source: Authors' calculations based on the data from the SDCEN.

Interprovincial Differences in the Pension Fund Balance.

The provincial pension fund balance, indexed by the ratio of revenue to expenditure of the pension fund, is shown in Fig. 2. In early 2002-2022, the provincial ratio of revenue to expenditure of the pension fund was larger than 1, indicating that annual revenue could support expenditure and the pension fund had a positive annual balance, and interprovincial differences were minor and fluctuated within a narrow range. However, from 2008 the balances of some provinces grew faster than the others. By 2014, the quantity of provinces with pension fund deficits (i.e., the ratio of revenue to expenditure of the pension fund is less than 1) increased and interprovincial differences became larger. In 2020, due to global COVID-19, more provinces fell into deficits, the average fund balance (represented by the thin dashed line in Fig. 2) got worse, and the interprovincial differences shrank and rebounded until 2022.

Then, the interprovincial differences in the population mobility rate and pension fund balance increase gradually, and there is a specific correlation between them.

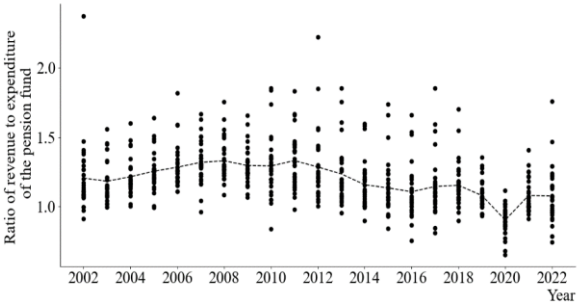

Fig. 2. Trends in the provincial ratio of revenue to expenditure of the pension fund
Source: Authors' calculations based on the data from the SDCEN.

4 Analysis of Empirical Results

We use Stata software to make LLC (Levin-Lin-Chu), IPS (Im-Pesaran-Skin), and Kao tests. The results show that the explained variable and the core explanatory variable have the same order unit roots, being cointegrated. So we can proceed with regression. Next, the Hausman test indicates that, at a 1% significant level, the hypothesis that individual and time effects are not correlated with explanatory variables is rejected. Then, the fixed effects model instead of the random effects model is appropriate.

4.1 The Average Effect

By Equation (7), progressively adding control variables, the OLS regression results in columns (1) - (3) in Table 2 confirm the negative average effect of population mobility on the pension fund balance. We focus on coefficients of the core explanatory variable *Plr*, which are significant at the 1% or 5% significance levels. Comparing the three columns, the standard errors are almost unchanged, but the *R*-squared rises, indicating the explanatory power of regression models is improved. From Column (3), the coefficient is -0.557 and significant at the 1% significance level. That is, on average, when the population mobility rate increases by 1%, the ratio of revenue to expenditure of the pension fund will decrease by 0.557%. The *R*-squared equals 0.506, signifying a 50.6% change in the ratio of revenue to expenditure of the pension fund can be explained.

4.2 Provincial Individual Effects

By Equation (8), results in Table 3 reflect that the provincial individual impacts of population mobility on pension fund balance are apparent. From Column (1) to Column (3), to most provinces, the coefficient standard errors change in a small amplitude or decrease. The *R*-squared upgrades from 0.542 to 0.592, and finally to 0.626. All show that the overall significance level (or explanatory power) of the equation is enhanced. Seeing Column (3), at the 5% significance level, provinces whose effects (coefficient

absolute values) are ranked from the largest to smallest are as follows: Fujian, Shanxi, Shandong, Tibet, Guangdong, Ningxia, Shannxi, Hainan, Qinghai, Henan, Anhui, Jiangxi, Chongqing, Zhejiang, Gansu, Beijing, Guangxi, and Shanghai. Among them, the coefficient absolute values of the top 10 provinces are larger than 2, which implies that for every 1% increase in population mobility, the change in the ratio of revenue to expenditure of the pension fund is more than 2%.

Table 2. Results of regression (average effect)

Variable	(1)	(2)	(3)
Plr	-0.277***(0.10)	-0.249**(0.12)	-0.557***(0.14)
Fold		-0.147(0.42)	-0.309(0.45)
Popu_rural			-172.473***(38.68)
Averscole		1.276(4.65)	2.806(4.63)
Numer_re		-6.157***(1.08)	-7.619***(1.11)
Numer_pen		0.482(0.33)	0.799**(0.32)
Budgetex		0.096(0.08)	0.340**(0.16)
Tech			0.485***(0.15)
Educ_inc			-0.028***(0.01)
Enterprise			-3.189**(1.54)
Poor			-16.702***(3.22)
Constant	119.601***(2.43)	121.897***(16.61)	213.716***(21.92)
Individual fixed effects	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes
R-squared	0.410	0.459	0.506
Observations	651	651	651

Source: results of Stata software processing.

Notes: *p<0.10, **p<0.05, ***p<0.01; numbers in parentheses are standard errors.

Table 3. Results of regression (individual effects)

Variable	Province	(1)	(2)	(3)
Plr_{ah}	Anhui	1.613**(0.71)	1.938***(0.70)	1.757**(0.72)
Plr_{bj}	Beijing	-1.369***(0.21)	-0.944***(0.22)	-1.006***(0.13)
Plr_{fj}	Fujian	-9.436***(2.90)	-6.279**(2.81)	-9.241***(1.31)
Plr_{gs}	Gansu	-0.957(0.91)	-1.545*(0.91)	-1.229**(0.59)
Plr_{gd}	Guangdong	0.498(0.51)	4.375***(1.01)	5.005***(1.17)
Plr_{gx}	Guangxi	-0.749(0.56)	-0.698(0.54)	-0.820***(0.29)
Plr_{gz}	Guizhou	0.716*(0.41)	0.447(0.41)	0.313(0.26)
Plr_{hn1}	Hainan	-2.228**(0.91)	-1.584*(0.90)	-2.457***(0.45)
Plr_{hb1}	Hebei	-2.645(1.84)	-2.018(1.81)	0.024(1.14)
Plr_{hn2}	Henan	-1.641***(0.62)	-1.560**(0.62)	-2.192***(0.65)
Plr_{hlj}	Heilongjiang	-0.903(0.66)	0.317(0.69)	-0.029(0.50)
Plr_{hb2}	Hubei	2.410(2.71)	1.173(2.58)	0.464(0.74)

Plr_{hn3}	Hunan	-0.632(0.84)	0.140(0.81)	0.395(0.56)
Plr_{jl}	Jilin	-1.780**(0.85)	-1.144(0.87)	-0.586(0.55)
Plr_{js}	Jiangsu	-0.576(1.80)	-2.980(1.99)	-1.472(1.61)
Plr_{jx}	Jiangxi	0.171(0.81)	0.806(0.79)	1.536**(0.57)
Plr_{ln}	Liaoning	8.290**(3.88)	6.057(3.71)	2.068(2.03)
Plr_{nmg}	Inner Mongolia	-2.397(2.70)	-1.394(2.60)	-0.058(1.62)
Plr_{nx}	Ningxia	4.250***(1.29)	6.024***(1.30)	4.600***(0.95)
Plr_{qh}	Qinghai	-1.016(0.83)	-2.103**(0.82)	-2.222***(0.63)
Plr_{shd}	Shandong	-6.599(6.31)	-2.809(6.02)	-6.168**(2.87)
Plr_{shx1}	Shanxi	-6.778***(2.13)	-8.138***(2.05)	-6.981***(0.86)
Plr_{shx2}	Shannxi	-0.111(1.85)	-1.222(1.78)	-2.556***(0.79)
Plr_{shh}	Shanghai	-0.405**(0.20)	-0.274(0.20)	-0.384**(0.17)
Plr_{sc}	Sichuan	-0.351(1.26)	1.453(1.25)	0.718(0.58)
Plr_{ti}	Tianjin	0.158(0.24)	0.213(0.23)	0.148(0.11)
Plr_{xz}	Tibet	4.525***(1.21)	6.139***(1.17)	5.310***(0.46)
Plr_{xj}	Xinjiang	0.390(0.62)	0.861(0.60)	0.442(0.31)
Plr_{yn}	Yunnan	1.901*(1.15)	0.803(1.15)	-0.582(0.67)
Plr_{zj}	Zhejiang	1.781***(0.36)	1.300***(0.45)	1.331***(0.36)
Plr_{cha}	Chongqing	-1.017(1.12)	-2.026*(1.10)	-1.464***(0.52)
Fold			-0.604(0.44)	-0.472(0.33)
Popu_rural				-49.429(64.19)
Averscole			-20.001***(4.82)	-15.834*(8.41)
Numer_re			-6.083***(1.42)	-6.539***(1.29)
Numer_pen			2.121***(0.48)	2.550***(0.52)
Budgetex			-0.019(0.09)	0.321(0.21)
Tech				0.354*(0.21)
Educ_inc				-0.023**(0.01)
Enterprise				-3.116(2.34)
Poor				-19.941***(4.10)
Constant		118.296***(2.38)	196.567***(17.01)	253.214***(35.91)
Individual fixed effects		Yes	Yes	Yes
Time fixed effects		Yes	Yes	Yes
R-squared		0.542	0.592	0.626
Observations		651	651	651

Source: results of Stata software processing.

Notes: *p<0.10, **p<0.05, ***p<0.01; numbers in parentheses are standard errors.

4.3 Interprovincial Differences

When we take the average effect in Table 2 as a benchmark, the interprovincial differences in the effects of population mobility on the pension fund balance can be reflected by the deviation of provincial individual effects from the average effect. If the absolute value of the former exceeds that of the latter, the provincial differences are more considerable. At the 5% significant level, the provincial differences are greater in some provinces (Fujian, Shanxi, Tibet, Shandong, Guangdong, Ningxia, Anhui, Jiangxi, Shannxi, Hainan, Zhejiang, Qinghai, and Henan), and tiny in Chongqing, Gansu, Beijing, Guangxi, and Shanghai, not significant in other provinces. The reasons may be the

following: firstly, the population mobility is different in each province, generally moving from the central and western provinces to the eastern ones, or from less developed regions to developed ones. Secondly, the mobile population may participate in one of China's two pension systems (the PSUE or PSR). We only analyze the effects on the PSUE, and if the mobile population chooses the PSR, the effects will be more minor or insignificant. Then, the above results can confirm the previous hypothesis.

5 Conclusions

Under China's provincial pooling model of pension systems, population mobility between provinces has significant effects on the pension fund balance, as indicated by the ratio of revenue to expenditure of the pension fund. Firstly, the effects in each province are different. Population mobility changes the proportion of contributing and retired population covered by a pension system, and population outflow decreases the pension fund revenue. The effects in many provinces are significant at the 5% significance level. For the top 10 provinces, with a 1% increase in population mobility, the ratio of revenue to expenditure of the pension fund will decrease by more than 2%. Secondly, by the deviation of provincial individual effects from the average effect, interprovincial differences in the effects of population mobility on pension fund balances are strong in some provinces and weak or insignificant in others.

Population mobility is inevitable in the development of human society. With the flourish of big data processing technology, governments should promote the digital management of public pension systems by monitoring population mobility.

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