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Will Population Aging Attract Foreign Investment?

-- An Empirical Study based on Provincial Panel Data in China

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Abstract. Drawing on provincial panel data from China spanning 2005 to 2020, this paper investigates the impact of population aging on Foreign Direct Investment (FDI), integrating innovation levels and human capital within the analysis. Utilizing a two-way fixed effects model, a inverted U-shaped relationship between population aging and FDI inflows is identified, with spatial heterogeneity observed. Heterogeneity analysis across China's Eastern, Central, and Western regions shows that only the Eastern region demonstrates a pronounced inverted U-shaped relationship, emphasizing the role of regional economic development, industrial structures, and degrees of openness. Additionally, regional innovation levels and human capital exhibit significant positive effects on FDI, with the dynamic influenced by population aging also displaying an inverted U-shaped trend. Thus, policymakers should consider region-specific economic and demographic conditions to optimize FDI-related policies and leverage regional innovation capabilities and human capital to promote FDI inflows.

Keywords: Population Aging; Foreign Direct Investment; Technological Innovation; Human Capital.

1. Introduction

Population aging is a major global challenge today. With improvements in healthcare and living conditions, as well as declining fertility rates, the proportion of elderly people is increasing, leading to significant demands for social elderly care services and medical security. China, one of the world's most populous countries, is also facing this issue. By the end of 2022, China's elderly population aged 60 and above had reached 280.04 million, accounting for 19.8% of the total population; those aged 65 and above numbered 209.78 million, accounting for 14.9% of the total population. This trend not only impacts families and communities but also presents new challenges for the country's social policies and economic development.

At the same time, demographic factors have profound effects on Foreign Direct Investment (FDI), especially in populous countries like China. Changes in the labor force age structure in China, with rising labor costs and decreasing labor supply, are influencing foreign investment decisions. By 2023, the proportion of China's working-age population (15 to 59 years old) had gradually declined, prompting some foreign investors in labor-intensive industries to seek automation and technological innovation to reduce labor dependency. Additionally, changes in China's population structure have driven an increase in FDI in the service and consumer sectors. As the middle class expands and consumer preferences change, foreign investors are increasingly investing in industries such as healthcare, education, and financial services. FDI in China, against the backdrop of population aging, has shifted. Rising labor costs have led some labor-intensive foreign enterprises to relocate to countries with lower labor costs, such as Vietnam and Indonesia, affecting China's job market and prompting its economic transition toward technology and capital-intensive industries. FDI has also promoted China's development in healthcare and elderly care services, introducing advanced technology and managerial expertise to enhance service quality and efficiency.

In summary, the relationship between China's population aging and Foreign Direct Investment (FDI) is complex and multidimensional. On one hand, FDI outflows have accelerated China's economic industrial upgrading, shifting it from the "world's factory" to the "world's laboratory". On the other

hand, foreign investment in elderly care and medical industries has addressed challenges from population aging, enhancing efficiency and quality of healthcare and elderly care services through technological and managerial innovations. This study approaches the issue from three angles. Firstly, it explores the nonlinear relationship between population aging and FDI to better understand and predict aging's economic impact, providing a more accurate basis for regional investment policies. Secondly, it introduces human capital levels and technological innovation as mechanism variables, investigating their mediating role in population aging's impact on FDI inflows. Lastly, it considers significant political and economic differences among China's eastern, central, and western regions, showing population aging's complex influence on FDI inflows across different areas. This study enhances academic understanding and offers practical policy recommendations for more effective economic and social development strategies.

2. Theoretical Analysis and Research Hypotheses

The impact of population aging on Foreign Direct Investment (FDI) is complex and widely studied. Research suggests that population aging affects FDI through various mechanisms, with outcomes depending on economic environments and policies. From a positive perspective, an increased dependency ratio can lead to a deficit in the current account balance, attracting higher capital inflows (Kim & Lee, 2008). There is also a trend of capital flowing from countries with lower to higher dependency ratios (Zhu, 2018). Moreover, as aging deepens, labor supply and capital accumulation decline, prompting a shift to capital-intensive industries and boosting FDI (Li & Deng, 2018). However, the decline in natural interest rates as aging progresses may negatively impact FDI attractiveness (Yi et al., 2021; Wang, 2012).

In summary, population aging affects FDI inflows through various dimensions, with a possibly nonlinear relationship. Initially, aging may stimulate FDI due to low labor costs and deficits in the current account balance. However, as aging continues, factors like the decline in the labor force and falling interest rates may inhibit FDI. Therefore, this study proposes the hypothesis:

Hypothesis 1: There is a nonlinear relationship between population aging and Foreign Direct Investment.

Apart from its direct impact on Foreign Direct Investment (FDI), population aging also influences technological innovation, thereby indirectly affecting FDI. Some studies have approached this issue from the perspectives of population policy, R&D investment, and factor substitution, finding that when the level of population aging is below a certain critical threshold, it is conducive to technological innovation. However, when the level of population aging exceeds this threshold, it may inhibit technological innovation (Chang et al., 2022; Yang et al., 2018). Other research suggests a linear relationship, with population aging overall promoting labor-saving technological innovation (Wei & Gu, 2023) but potentially dampening the positive impact of technological innovation on economic development (Si & Jiang, 2023). Technological innovation, in turn, affects FDI by enhancing a country's industrial competitiveness and innovation capacity, attracting more FDI. However, it may also deepen technological disparities, attracting FDI to technologically advanced countries. Thus, this paper posits the hypothesis:

Hypothesis 2: Population aging can affect FDI inflows through the level of regional technological innovation.

As the degree of population aging increases, the development of human capital also undergoes changes. On one hand, when the degree of population aging is relatively low, the labor market is relatively abundant, and there is an ample supply of labor resources, which helps drive technological innovation and economic growth. On the other hand, when the degree of population aging is too high, there may be a shortage of labor supply in the labor market, leading to the loss of human capital and insufficient innovation momentum.

Based on the theory of human capital, Dunning (1981) combines human capital with Foreign Direct Investment (FDI) and extends it to the theory of eclectic paradigm. He believes that human capital is a major non-natural factor that causes regional differences in advantages and is also an important component in attracting FDI. Therefore, the level of human capital in a region not only affects the economic growth of that region but also affects its ability to attract FDI, thus having a negative impact on the regional economy. Li et al. (2019) argue that when the level of human capital is low, its role in attracting FDI is relatively weak. When the level of human capital is moderate, its role in attracting FDI is strongest. However, when the level of human capital is high, its role in attracting FDI decreases. Similar literature includes Yuan et al. (2019), Feng et al. (2015), among others. Given this, this paper proposes the following hypothesis:

Hypothesis 3: Population aging can affect FDI inflows through the level of human capital.

3. Methods and data

3.1. Data Sources

This paper utilizes panel data from 30 provinces in China spanning the years 2005 to 2020 to examine the impact of population aging on Foreign Direct Investment (FDI) inflows, comprising a total of 480 observations. The data mainly originate from the statistical yearbooks of each province and the EPS database.

3.2. Variable Setting

Table 1. Variables and their Descriptions

Variable Type	VARIABLE NAME	VARIABLE SYMBOL	VARIABLE DEFINITION
Dependent Variable	Foreign Direct Investment	FDI	Proportion of actual utilization of foreign capital to GDP in 30 provinces of China
Independent Variables	Population Aging	Aging	Proportion of population aged 60 and above to total population in each province
Control Variables	Industrial Structure	Structure	Output value of tertiary industry / output value of secondary industry
	Urbanization Rate	City	Urban population / total population of each province
	Economic Development Level	GDPPC	Per capita regional gross domestic product index
	Environmental Regulation	ER	Investment in industrial pollution control
	Wage Level	Salary	Average wage of urban employees (in RMB) per capita
Mediating Variables	Innovation Level	Innovate	Logarithm of the number of patent applications for inventions received
	Human Capital	HC	Proportion of students enrolled in higher education institutions (in ten thousand people) to total population

(1) Dependent Variable

Given the existing research findings and the practical differences among provinces in attracting Foreign Direct Investment (FDI), this study selected 30 provinces, autonomous regions, and municipalities directly under the central government excluding Tibet and the Hong Kong, Macao, and Taiwan regions as research subjects. The annual actual utilization of FDI was used as the basic data.

(2) Explanatory Variable

This paper uses the proportion of the population aged 60 and above as an indicator of population aging, denoted by "Age." This measure was selected for its direct representation of the elderly's share in the total population, providing a clear metric for analyzing demographic structure changes.

(3)Control Variables

To explore how aging influences Foreign Direct Investment (FDI), this study includes control variables such as industrial structure, urbanization rate, economic development level, environmental regulations, and wage levels. These factors significantly affect FDI flows and scales. Industrial structure shapes regional competitiveness and attractiveness to FDI; urbanization rate indicates infrastructure quality, influencing foreign investment preferences; economic development reflects market size and potential, key for investment decisions; environmental regulations affect business costs and risks, particularly impacting investments in pollution-intensive industries; and wage levels relate directly to labor costs, influencing FDI in different industries.

3.3. Descriptive Statistics

Table 2. Descriptive Statistics

	(1)	(2)	(3)	(4)	(5)
Descriptive Statistics	Obs	Mean	Std. Dev	Min	Max
Aging	480	0.100	0.0228	0.0547	0.174
Fdi	480	0.0247	0.0184	0.000103	0.0851
Structure	480	1.092	0.628	0.500	5.297
City	480	0.552	0.140	0.269	0.896
GDPPC	480	11,996	7,708	3,264	47,118
HC	480	0.0183	0.00620	0.00554	0.0413
ER	480	2.010	1.936	0.00476	14.16
Salary	480	5.179	2.808	1.369	18.50
Innovate	480	2.167	0.198	1.475	2.508
Number of state	30	30	30	30	30

4. Empirical Results and Economic Interpretation

4.1. Baseline Regression

In this paper, to thoroughly investigate the impact of population aging on Foreign Direct Investment (FDI) and considering the panel data characteristics covering multiple time periods and regions, a two-way fixed effects model is chosen as the baseline regression model. The model constructed for this analysis is as follows:

$$FDI_{it} = \beta_0 + \beta_1 Age_{it} + \beta_2 Age_{it}^{2} + \lambda_K Control_{it} + \mu_i + \nu_t + \xi_{it} \quad (1)$$

In this paper, FDI_{it} represents the Foreign Direct Investment level for region i in year t, serving as the dependent variable; Age_{it} denotes the aging index for region i in year t , with its quadratic term Age_{it}^2 capturing the nonlinear aging-FDI relationship. Coefficients β 1 and β 2 represent the linear and quadratic aging terms. A significant β 2 indicates a nonlinear aging-FDI relationship, its specific nature (inverted U-shaped or U-shaped) determined by its sign. $Control_{it}$ includes control variables; μ i represents regional fixed effects, Vt denotes time fixed effects, and ε it is the random error term. Regression results are summarized in Table 3.

Table 3. Baseline Regression Results

	(1)	(2)
	FDI	FDI
Age	1.666***	1.565***
	(0.238)	(0.230)
Age^2	-5.768***	-5.245***
	(0.966)	(0.931)
Structure		-0.000
		(0.003)
City		0.024
		(0.030)
GDPPC		0.008
		(0.007)
ER		-0.000
		(0.001)
Salary		0.058***
		(0.011)
_cons	-0.069***	-0.711***
	(0.014)	(0.099)
Obs	480	480
R^2	0.179	0.263
Year fixed effect	Yes	Yes
State fixed effect	Yes	Yes

Note.*, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. Standard errors are shown in parentheses, and apply to subsequent tables as well.

Table 3 displays the relevant results of the baseline regression. Model 1 introduces no control variables, while Model 2 includes them. Regression analysis reveals a consistently positive coefficient for the linear term of population aging (Age) and a negative coefficient for the quadratic term, indicating a significant inverted U-shaped relationship between population aging and foreign direct investment.

4.2. Robustness Test

(1). Lagging the Core Explanatory Variable

This paper addresses potential endogeneity between the dependent and explanatory variables by lagging the population aging indicator by one period. This analytical approach assumes that the effects of population aging may not be immediate but occur after a certain time lag, influencing FDI. Therefore, introducing a lagged variable helps capture this dynamic change process and provides more accurate and robust estimates. As shown in Model 4(1) in the diagrams, the coefficient for the quadratic term is -6.757, significant at the 1% level. This indicates that, even after accounting for

potential estimation biases caused by bidirectional causality among contemporaneous variables, the impact of population aging on FDI still exhibits a nonlinear pattern of initially positive followed by negative effects, further confirming the inverted U-shaped relationship between population aging and FDI.

Table 4. Robustness Test

	(1)	(2)	(3)
	Lagged one period	Replacement of Core Explanatory Variable	Instrumental Variable
L.Age1	1.801***		
	(0.266)		
$L.Age^2$	-6.757***		
	(1.127)		
Older		0.825***	
		(0.136)	
$Older^2$		-0.018***	
		(0.004)	
L.Age1			2.375***
			(0.331)
$L.Age^2$			-7.991***
			(1.219)
Obs	450	480	450
R^2	0.237	0.252	0.210
C-D Wald F	/	/	109.497
Year fixed effect	Yes	Yes	Yes
State fixed effect	Yes	Yes	Yes
Controls	Yes	Yes	Yes

(2)Substituting the Core Explanatory Variable

This study employs an alternative approach by substituting the proportion of elderly population (Age) with the old-age dependency ratio (Older). The results indicate that after this substitution, the direction and significance of the variables remain unchanged. The linear term coefficient is 1.801, significant at the 1% level, and the quadratic term coefficient is -6.757, also significant at the 1% level. Although there are some changes in coefficient magnitudes, they do not alter the fundamental signs. Thus, this method is reliable, further affirming the hypothesis of an inverted U-shaped relationship between population aging and Foreign Direct Investment (FDI).

(3)Instrumental Variable Approach

To address potential endogeneity in the analysis of population aging's impact on Foreign Direct Investment (FDI), this study uses the lagged one-period population aging rate as an instrumental variable. This strategy leverages the delayed effects between economic behavior and demographic changes, assuming that the impact of aging unfolds over time. By using the natural temporal variation

of the aging rate as a quasi-natural experiment, this approach reduces biases from omitted variables and potential bidirectional causality. Results shown in Model (3) with a high Cragg value of 109.497 confirm the effectiveness of this instrument. This strong statistic supports the robustness of the lagged aging rate as an instrumental variable, demonstrating its strong correlation with the endogenous variable and lack of correlation with the error term. This methodology significantly enhances the study's reliability and robustness, facilitating a clearer interpretation of population aging's nonlinear effects on FDI.

4.3. Heterogeneity Analysis

In this study, China is divided into three main regions—East, Central, and West—based on administrative divisions, aiming to explore how population aging impacts Foreign Direct Investment (FDI) inflows under different economic development levels and market conditions. The regression results are presented in Table 5.

Table 5. Heterogeneity Test by Region

	(1)	(2)	(3)
	Eastl	Central	West
Age	-0.677	0.396	2.426***
	(0.433)	(0.252)	(0.476)
Age^2	3.362*	-0.872	-8.753***
	(1.937)	(0.932)	(1.919)
Structure	-0.011***	-0.013**	0.006
	(0.004)	(0.005)	(0.006)
City	0.026	0.147*	-0.111*
	(0.049)	(0.075)	(0.058)
GDPPC	-0.034***	-0.011	0.006
	(0.011)	(0.010)	(0.013)
ER	0.002	-0.004***	0.003
	(0.002)	(0.001)	(0.002)
Salary	-0.016	0.037***	0.064***
	(0.016)	(0.014)	(0.022)
_cons	0.490***	-0.269**	-0.760***
	(0.179)	(0.127)	(0.190)
Obs	128	176	176
R^2	0.039	0.192	0.561
Year fixed effect	Yes	Yes	Yes
State fixed effect	Yes	Yes	Yes

This study provides a detailed examination of provincial data across China's Eastern, Central, and Western regions, uncovering significant regional differences in the relationship between population aging and Foreign Direct Investment (FDI). Regression results indicate an inverted U-shaped relationship between aging and FDI in the Eastern region only. This highlights the critical role of economic development level and market maturity in the aging-FDI interaction. The Eastern region's

developed market and advanced services sector create favorable conditions for attracting FDI, promoting growth in the early stages of aging. However, as aging deepens, labor market constraints and shifts in consumption negatively impact FDI. By contrast, the Central and Western regions, with lower development and openness levels, do not exhibit a significant inverted U-shaped pattern, suggesting different dynamics in how aging affects FDI attractiveness in these areas.

5. Identification and Verification of Mechanism Paths

The first half of this paper discusses the direct impact of population aging on the inflow of foreign direct investment (FDI). In the mechanism analysis, this paper will also examine the impact of population aging on foreign direct investment from the indirect paths such as regional innovation level and human capital.

5.1. Regional Innovation Level

This paper uses the logarithm of domestic patent applications to measure the innovation levels of provinces and examines whether population aging affects Foreign Direct Investment (FDI) by influencing regional innovation levels. The regression results, as shown in Table 6, indicate that the quadratic term coefficient is -13.559 and the linear term coefficient is 2.688, both significant at the 1% level, suggesting an inverted U-shaped relationship between population aging and urban innovation levels. These results imply that in the early stages of aging, innovation activities are initially promoted due to the accumulation of social experience and capital, with an increasing elderly population potentially contributing to greater knowledge accumulation and innovative experience, thereby enhancing innovation levels. However, as aging progresses, the tightening of the labor market, the reduction in young innovative talents, and changes in consumer demands may begin to inhibit innovation activities, leading to a slowdown or decline in innovation levels.

Table 6. Mechanism Identification of Population Aging on Foreign Direct Investment

	(1)	(2)	(3)	(4)
	Innovate	FDI	HC	FDI
Age	2.688***		0.106***	
	(0.790)		(0.031)	
Age^2	-13.559***		-0.340***	
	(3.196)		(0.125)	
Innovate		0.027*		
		(0.015)		
HC				0.676*
				(0.374)
Obs	480	480	480	480
R^2	0.923	0.169	0.836	0.168
Year fixed effect	Yes	Yes	Yes	Yes
State fixed effect	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes

The positive coefficient of 'Innovate' in column (2) of Table 6 indicates that higher urban innovation levels can increase FDI. Regions with high levels of innovation attract more foreign investment, likely because technological innovation enhances the region's industrial competitiveness, offering more collaboration opportunities and greater market potential to foreign enterprises. Additionally, regions

with high innovation levels often have better infrastructure and higher quality human resources, which are crucial factors for foreign enterprises when considering investment locations. Therefore, Hypothesis 2 is supported.

5.2. Human Capital

This paper employs the proportion of students enrolled in institutions of higher education to the total population as a measure of the human capital level in each province. Through this approach, human capital is introduced as a mediating variable to examine whether the impact of population aging on Foreign Direct Investment (FDI) operates through its effect on regional human capital levels. From the empirical analysis in column (3) of Table 6, it is found that a quadratic relationship exists between population aging and human capital, indicating that in the early stages of population aging, social and economic development typically coincide with changes in employment structures and the emergence of new industries, leading to a greater demand for highly skilled and educated labor. As population aging deepens, declining fertility rates and an increasing proportion of elderly population lead to an overall decrease in labor market supply, especially with a reduction in the number of young people entering the labor market. In such circumstances, even if the rate of higher education remains unchanged, the total number of young individuals entering higher education systems will decrease, thereby impacting the overall quality and quantity of the new generation workforce.

The significant positive coefficient of 'HC' in column (2) further validates the importance of a high-quality workforce in attracting foreign investment. This suggests that although population aging may pose a series of challenges, enhancing education levels and nurturing highly skilled talents can effectively elevate the region's human capital level, thereby promoting the growth of Foreign Direct Investment. Therefore, Hypothesis 3 is supported.

6. Research Conclusion and Policy Implications

Based on the data spanning 15 years from 30 provinces in China, this study delves into the mechanism through which population aging affects Foreign Direct Investment (FDI), particularly through the mediating roles of regional innovation level and human capital. Empirical results reveal a non-linear relationship between population aging and FDI, indicating a positive impact during the initial phase of aging, followed by a negative effect as aging progresses. Further heterogeneity analysis shows that only in the eastern region, a significant inverted U-shaped relationship exists between population aging and FDI. This disparity reflects substantial differences among regions in China concerning economic development, industrial structure, and openness to the outside world, and how these variances influence the specific pathways through which aging affects FDI. The eastern region, being the most economically developed and open in China, exhibits higher innovation capability and human capital levels, thus effectively attracting FDI during the initial stages of population aging. However, the central and western regions, due to relatively insufficient conditions, show less significant positive effects of population aging on FDI and its mediation through innovation and human capital compared to the eastern region. Additionally, regional innovation level and human capital play a facilitating role in the inverted U-shaped relationship between population aging and FDI inflows.

Based on these findings, the study proposes the following policy recommendations: First, policymakers should address the dual impacts of population aging. When formulating relevant policies, policymakers should recognize that population aging not only brings challenges but also provides opportunities to promote economic adjustment and upgrading. During the initial phase of aging, policies should encourage investment in education and innovation activities to leverage the initial positive effects of aging. Second, enhance regional innovation level and human capital. The findings underscore the importance of improving the education level and cultivating high-skilled talents for attracting FDI. Policymakers need to enhance regional innovation capability and human capital level through measures such as improving the education system, increasing investment in research and development, and optimizing talent training mechanisms. Third, adopt differentiated

development strategies according to local conditions. Given the heterogeneity in the impact of population aging on FDI across eastern, central, and western regions, policymakers should formulate differentiated strategies based on the specific circumstances of each region. The eastern region should focus on leveraging its advantages in high innovation level and human capital to continue attracting high-quality FDI, while the central and western regions need policy support to accelerate the construction of education and innovation systems to enhance their attractiveness to FDI. Finally, promote high-quality economic development. With the deepening of population aging, it is necessary to focus more on promoting high-quality economic development through technological innovation and the cultivation of high-skilled talents. This can not only help overcome the challenges brought by population aging but also provide new impetus for sustained economic growth.

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