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Effects of Population Loss on Basic Public Service Provision in Cities: An Analysis of 110 Cities in the Yangtze River Economic Belt

Hao Liang*, Jiamin Deng
College of Humanities and Foreign Languages, China Jiliang University, Hangzhou, China
**Corresponding Author*

Abstract: Against the background of negative population growth and widening regional population differentiation in China, population shrinkage has become an important issue for urban public service governance. This paper compiles city-level panel data encompassing 110 prefecture-level cities across the Yangtze River Economic Belt during the period 2010–2024, identifing shrinking cities based on continuous negative growth in permanent residents, constructs a six-dimensional evaluation index system for the basic public services supply in cities, and measures the composite level through an entropy-weighted TOPSIS method. A two-way fixed effects model, mediation model and grouped regressions are then employed. The results show that population shrinkage significantly affects the provision of urban basic public services. Fiscal expenditure partly mediates this relationship. The negative impact is more pronounced in upstream and midstream cities, while it is insignificant in downstream cities; it is also significant in mildly and deeply shrinking cities but insignificant in occasionally shrinking cities. The findings suggest that public service governance under population shrinkage should shift from expansion-oriented provision to bottom-line protection, targeted fiscal support and differentiated adjustment.

Keywords: Population Shrinkage; Urban Basic Public Services; Fiscal Expenditure; Yangtze River Economic Belt

1. Introduction

The basic public services supply is an important component of urban governance and people's livelihood security. Supply conditions directly affect urban residents' well-being, social justice, and long-term urban sustainability. With the advancement of urbanization, the population continues to concentrate on the core cities, while the peripheral cities are facing the population loss. The urban population pattern gradually shows the differentiation characteristics of agglomeration and local contraction. Affected by this, the past practice models of public services, which were proposed based on population growth and urban expansion trends, has brought problems such as idle resources and mismatch between supply and demand to some minor cities. Therefore, in the context of population shrinkage, how to shift the supply mode of urban basic public services from incremental expansion to stock optimization and structural adjustment holds great significance for optimizing public resource allocation and promoting the equalization of basic public services.

Population shrinkage is generally defined as a sustained decline in the size of the population over a given period. It can be identified using single indicators such as the permanent resident population growth rate or the average annual population change rate [1,2], or through multidimensional index comprehensive measurement like age structure, economy, and land use [3,4]. The emergence of population shrinkage stems from a variety of factors; low fertility rates, an aging population, deindustrialization and industrial decline, as well as uneven regional development, can all contribute to population outflow in certain regions [5,6]. In turn, population shrinkage will have economic and social effects on regional sustainable development. Scholars have conducted research on how to address population shrinkage and have proposed two fundamental strategies: "resisting contraction" and "adapting to contraction" [7,8]. The former believes that population shrinkage is temporary and reversible, and that active policy intervention should be taken to change the trend of population outflow; however, such measures may exacerbate fiscal burdens and lead to wasteful use of public service

supply. The latter view emphasizes proactive adaptation, prioritizing the enhancement of urban development levels over merely pursuing expansion in terms of scale.

The existing research on basic public services is usually explained from the supply subject, the demand subject and the value goal. It is defined as the basic and inclusive service provided by the government to the people through public finance and institutional arrangements. chiefly designed to cater to the basic living and developmental demands of local residents, and reflects the value orientation of fairness, inclusiveness and welfare improvement [9]. Related research mostly constructs a comprehensive evaluation system from dimensions such as public education, medical and health care standards, social security systems, public culture, public infrastructure, and ecological environment. Some studies focus on subsystems such as health care and public culture, and analyze their supply levels and spatial differences [10, 11]. Scholars mainly use entropy the following methods to mitigate the impact of subjective weighting on research outcomes, such as the entropy method, TOPSIS method, principal component analysis, and factor analysis [12-14]. In terms of influencing factors, population size, population density and population structure changes will affect the demand for public services, especially in the aspects of population aging, low birth rate and new urbanization [15]. However, the existing research on the relationship between population and public services has primarily been conducted from the perspective of urbanization and population growth, paying more attention to expanding the demand for public services and the pressure of insufficient supply brought by population growth, while the public services supply in the context of population shrinkage is relatively insufficient.

The Yangtze River Economic Belt includes 11 provinces and municipalities and spans the eastern, central and western regions of China. It is an important strategic belt for China's economic development and regional coordination. Compared with typical population loss areas such as Northeast China, the Yangtze River Economic Belt population change is not a complete contraction, but presents the differentiation characteristics of the continuous agglomeration of population in core cities and the outflow of population in minor cities. Instead, although the cities within the Yangtze River Economic Belt are in a similar national policy environment, there are great differences in economic development level, industrial base, financial capacity and public service level, which provides comparable regional conditions for analyzing the basic public services supply in cities under the background of population shrinkage. Therefore, taking 110 cities within the Yangtze River Economic Belt as the research sample not only helps to analyze the influence of population shrinkage on urban basic public service provision and regional differences, but also provides a reference for population shrinking cities to improve the level of public service resource allocation and public service supply, promote regional coordinated development.

2. Theoretical Analysis and Research Hypotheses

2.1 Direct Effects of Population Shrinkage on the Supply of Urban Public Services

The shrinking of population is directly manifested in the reduction of urban resident population, which is an important basis for governments to allocate basic public services like education, medical and health care, and infrastructure. When the urban population continues to decrease, the number of objects served by the original public service resources changes correspondingly. In some areas, there may be a decrease in school enrollment, a decrease in public transport passenger flow, and insufficient use of cultural and sports facilities, which makes the existing public service supply and population change. There is a mismatch between them. Especially for some minor cities and less developed areas, it may be synchronized with the deepening of population aging. The demand for public services such as health care and old-age security may increase, while the demand for resource use such as education and public transportation may decrease [16]. This mismatch will reduce the efficiency of public resource utilization and greatly increase the pressure on local governments to maintain their original service levels. This study proposes research hypothesis H1: population shrinkage will significantly reduce the level of urban basic public service supply.

2.2 Indirect Impact of Population Shrinkage on the Supply Level of Basic Public Services

Adequate funding is essential for the development and supply of public services,

including education, healthcare, social security, and infrastructure. Generally speaking, local financial strength directly determines the quality of public service provision. The population shrinkage may affect local fiscal expenditure. On the one hand, the continuous outflow of population will compress the labor force and consumer market, and will also inhibit the development of urban industry and economic vitality, which may lead to the reduction of local tax sources and put fiscal revenue under pressure [17, 18]. On the other hand, there are often some problems in population shrinking cities, such as insufficient industrial development momentum and weak economic foundation, which will further affect the fiscal expenditure capacity of governments. In the case of fiscal revenue affected, local government funding for public service construction, facilities maintenance and service improvement may be limited, thus affecting the level of basic public service supply. In addition, the decrease in population does not mean that the expenditure on basic public services can be reduced simultaneously. Public services such as schools, hospitals, public transportation and infrastructure still need funds to maintain basic operations. Expenditure in social security, health care and other fields is also rigid [19]. Therefore, this study proposes a research hypothesis H2: population shrinkage may reduce the level of urban basic public service supply by affecting local fiscal expenditure.

2.3 Regional Variations in Basic Public Service Supply under Population Shrinkage

Due to the different regions of the city, the impact of population shrinkage on the supply level of urban basic public services may be different. The Yangtze River Economic Belt covers a vast area, and these regions vary considerably in economic development, industrial base, financial capacity, and public service level. According to the core-periphery theory, different cities in the region are not the same in terms of resource agglomeration capacity and development conditions. The core area is usually able to attract more population, capital and industry, while the relatively marginal areas are more likely to have problems such as population outflow and weakened development capacity. This regional difference will further affect the capability of local governments in providing basic public services. From the perspective of the Yangtze River Economic Belt, the downstream region has a high level of economic development, a good industrial base, a relatively stable source of fiscal revenue, and a relatively complete public service system like education, medical and health care, social security and infrastructure. Even if some cities have a population decline, they may rely on a strong economic base and financial capacity to sustain basic public service provision. In such cases, the influence of demographic shrinkage tends to be relatively limited. By contrast, the economic foundation of some cities in the middle and upper reaches is comparatively fragile, the industrial structure is relatively simple, and they are more sensitive to population outflow and fiscal revenue changes. In particular, some minor cities and underdeveloped areas may face multiple pressures such as population decline, insufficient financial support and weak public service foundation, and the level of basic public service supply is more vulnerable. Therefore, the impact of population shrinkage on the level of basic public service supply is not completely consistent, but may show differences between different regions. This study proposes a research hypothesis H3: the negative effect of population shrinkage on the level of basic public service supply shows the strongest gradient difference in the upstream region, the second in the middle reaches, and the weakest in the downstream region.

2.4 Heterogeneity by Degree of Contraction in How Population Decline Shapes Essential Public Service Provision

Population decline affects how urban essential services are provided, this effect may also vary due to the degree of population decline. According to the theory of urban life cycle, urban development will not always be in the stage of population expansion, but may experience different stages of growth, stability, adjustment and even contraction. The short-term decline in population may be only a temporary fluctuation in the process of urban development, which does not necessarily mean that the city has entered a state of continuous contraction. Conversely, when population decline persists over an extended period, it may signify that the city has entered a discernible phase of adjustment or shrinkage, with consequent effects on public service supply. Specifically, occasional population decline may be more influenced by short-term population mobility, changes in statistical caliber, or specific events, exerting a

relatively limited impact on the supply level of urban basic public services. For such cities, given the short duration of the population decline, arrangements for public service facilities and fiscal expenditure typically do not undergo immediate significant changes; local governments can still maintain basic public service provision as before. Compared to occasional shrinkage, mild and deep shrinkage indicate a degree of persistence in population decline. As the duration of population shrinkage lengthens, the permanent resident population continues to shrink, demand for public service resources such as education, public transport, and cultural and sports facilities may gradually decrease, and some facilities may become underused or idle. Simultaneously, the continued outflow of population may also affect local economic development and fiscal revenue, limiting the capacity of local governments to invest in public services. Especially for deep shrinking cities, the population decline lasts longer and the impact may be more pronounced. On the one hand, long-term population outflow will weaken the city's economic vitality and financial support capacity; on the other hand, the population shrinkage is often accompanied by the deepening of aging, and the expenditure pressure on health care and social security may increase. Therefore, in cities with different degrees of shrinkage, population shrinkage may influence basic public service provision differently. This study proposes the research hypothesis H4: the deeper the population shrinkage, the stronger the negative impact on the supply level of urban basic public services.

3. Research Design

3.1 Variable Choice and Data Sources

Table 1. Entropy Weight Calculation Results for Basic Public Service Provision Indicators

Dimension	Indicator Name	Indicator Type	Entropy Value (e_j)	Information Utility Value (1-e_j)	Index Weightings (w_j)	Weighting Percentage	Total Dimension Weights
Basic Education	Student-to-Teacher Ratio in Regular Elementary Schools (%)	Positive	0.991	0.009	0.026	2.597%	15.82%
	Student-to-Teacher Ratio in General Secondary Schools (%)	Positive	0.991	0.009	0.026	2.590%	
	General Secondary and Regular Elementary Schools (count per 10,000 residents)	Positive	0.979	0.021	0.064	6.445%	
	Full-time Teachers at Elementary Schools (persons per 10,000 residents)	Positive	0.986	0.014	0.042	4.183%	
Healthcare	Number of Healthcare Facilities per 10,000 People (units per 10,000 residents)	Positive	0.971	0.029	0.088	8.778%	15.55%
	Number of hospital beds per 10,000 People (beds per 10,000 residents)	Positive	0.985	0.015	0.045	4.520%	25.17%
	Number of Physicians per 10,000 People (count per 10,000 residents)	Positive	0.993	0.007	0.023	2.253%	
Social Security	Pension Insurance Coverage Rate (%)	Positive	0.976	0.024	0.072	7.160%	
	Health Insurance Coverage Rate (%)	Positive	0.972	0.028	0.085	8.536%	
	Unemployment Insurance Coverage Rate (%)	Positive	0.969	0.031	0.095	9.476%	
Public Culture	Number of books in public library collections per 10,000 People (10,000 copies per 10,000 residents)	Positive	0.955	0.045	0.136	13.641%	13.64%
Infrastructure	Urban Road Area per Resident (m²)	Positive	0.987	0.013	0.039	3.898%	28.59%
	Per capita park green space (square meters)	Positive	0.994	0.006	0.017	1.732%	
	Number of public buses (and trolleys) in operation at year-end per 10,000 People in urban districts (units per 10,000 residents)	Positive	0.978	0.022	0.065	6.528%	
	Number of Broadband Subscribers per 10,000 People (10,000 households per 10,000 residents)	Positive	0.967	0.033	0.098	9.841%	
	Length of Water Supply Pipelines per 10,000 People (kilometers per 10,000 residents)	Positive	0.978	0.022	0.066	6.589%	
Ecological Environment	Centralized Treatment Proportion of Wastewater Facilities (%)	Positive	0.998	0.002	0.006	0.552%	1.23%
	Domestic Waste Safe Treatment Rate (%)	Positive	0.999	0.001	0.003	0.251%	
	Share of Green Space in Built-up Areas (%)	Positive	0.999	0.001	0.004	0.429%	

3.1.1 Explained variable

The explained variable is the extent to which basic public services are provided. In order to ensure the systematicness, scientificity, representativeness and feasibility of index selection, this study combines entropy weighting with the TOPSIS technique. Drawing on indicator systems used in earlier research, it develops an indicator framework for assessing how well basic public services are provided. This framework

comprises six first-level indicators, including basic education, medical and health care, social security, public culture, infrastructure and ecological environment, and 19 second-level indicators [20,21]. Table 1 lists the measured outcome.

3.1.2 Explanatory variable

The explanatory variable is population shrinkage. Referring to relevant studies, this paper uses a dummy variable (Shrink) for identification. A city is identified as a shrinking city and assigned a value of 1 if it experiences two or more consecutive years of negative growth in its permanent resident population; otherwise, it is assigned a value of 0 [22]. The degree of shrinkage is classified based on the duration of population decline. Deeply shrinking cities are those with a cumulative total of 5 years or more of population decline during the sample period; these cities face severe structural contraction issues due to long-term and recurring population loss. Mildly shrinking cities are those with a cumulative total of 2 to 4 years of population decline; these cities exhibit a clear shrinking trend, though less sustained and severe than deeply shrinking cities. Occasionally shrinking cities are those with only 1 year of population decline during the sample period, indicating a single, short-lived, non-trend-setting contraction event. The identification results appear in Table 2.

Table 2. Identification Results of Population Shrinkage Types Based on Permanent Resident Population Indicator

Contraction Type	Evaluation Criteria	Number of Cities (units)	Percentage (%)
Non-shrinking	Number of Years of Contraction=0 years	35	31.81
Occasional shrinkage	Number of Years of Contraction=1 years	14	12.73
Mild shrinkage	Number of Years of Contraction=2—4 years	23	20.91
Severe shrinkage	Number of Years of Contraction≥5 years	38	34.55

3.1.3 Control variables

In order to control other factors that may affect urban basic public service supply, referring to relevant research [23,24], and select the regional economic development level, urbanization level and industrial structure as control variables. Regional economic development level is measured by adopting the logarithm form of per capita GDP. Generally, a higher economic development level means stronger local fiscal revenue and better resource allocation, which in turn allows for more investment into public services, specifically education, healthcare, and transportation. The level of urbanization is measured by the urbanization rate. The urbanization process will bring about changes in population concentration, infrastructure construction and public resource allocation efficiency, which will further affect basic public service supply. The industrial structure is reflected by the proportion of the added value of the tertiary industry to GDP. The higher proportion of the tertiary industry, it often means that the economic structure is more optimized, the employment absorption capacity is stronger, and it may also enhance public Fiscal expenditure capacity, thus influencing public service supply.

3.1.4 Data sources and processing

The empirical analysis relies on a panel dataset comprising 110 cities across the Yangtze River Economic Belt over the timeframe of 2010–2024. Data on population shrinkage and basic public services are mainly obtained from official yearbooks. These include the China City Statistical Yearbook, the China Urban Construction Statistical Yearbook, and provincial and municipal statistical yearbooks and bulletins. Missing data are supplemented by the EPS Data Platform and the China Economic Net Statistical Database. Linear interpolation are serves as a method to impute any remaining missing values.

3.2 Benchmark Model Specification

Grounded in the above theoretical reasoning and proposed hypothesis, this study uses the panel data covering 110 cities in the Yangtze River Economic Belt from 2010 to 2024, and the empirical regression employs a two-way fixed-effects approach. The specification is given below:

$$BPS_{it}=\alpha+\beta Shrink_{it}+\gamma Controls_{it}+\mu_i+\lambda_t+\varepsilon_{it} \quad (1)$$

Where BPS_{it} is the dependent variable, representing the supply level of basic public services for city i in year t calculated using the entropy-weighted TOPSIS method based on the constructed evaluation index system. $Shrink_{it}$ is the core explanatory variable, indicating whether city i is in a state of population shrinkage in year t. The model primarily focuses on the coefficient β, which indicates the average effect that population shrinkage has on the supply of basic public services. $Controls_{it}$ comprise per capita GDP, urbanization rate, and industrial structure. μ_i represents city fixed effects, controlling for time-invariant city-specific characteristics; λ_t denotes year fixed effects, controlling for common time-specific shocks; and ε_{it} is the random error term.

3.3 Mediation Variable Test Model Specification

To further analyze the mechanism through which population shrinkage affects the supply level of urban basic public services, this study uses local general public budget expenditure as a mediating variable for testing. The testing process is based on the total effect model, the mediator variable model, and the direct effect model, specified by the following equations:

$$Y_{it}=\alpha+\beta Shrink_{it}+\gamma Controls_{it}+\mu_i+\lambda_t+\varepsilon_{it} \quad (2)$$

$$Fiscal_{it}=\alpha+\beta Shrink_{it}+\gamma Controls_{it}+\mu_i+\lambda_t+\varepsilon_{it} \quad (3)$$

$$Y_{it}=\alpha+\beta Shrink_{it}+\theta Fiscal_{it}+\gamma Controls_{it}+\mu_i+\lambda_t+\varepsilon_{it} \quad (4)$$

Where, Y represents the urban basic public service supply level, *Shrink* represents the population shrinkage degree, *Controls* is the set of control variables, μ_i and λ_t control for city and year fixed effects, respectively.

4. Empirical Analysis

4.1 Descriptive Statistical Analysis

Table 3 presents the summary statistics of the core variables, providing an overview of their basic attributes. The average value of the comprehensive supply score (BPS) of the supply level of basic public services in cities is 0.191, the standard deviation is 0.050, the minimum value and the maximum value are 0.084 and 0.454, respectively, indicating that there are some differences in the supply level of basic public services in cities in the Yangtze River Economic Belt. The mean value of the Shrink variable is 0.283, indicating that population shrinkage occurred in about 28.3 % of the area during the sample period. The mean value of the fiscal expenditure (lnFiscal) variable is 5.905, and the standard deviation reaches 0.789, reflecting uneven fiscal expenditure among cities. In addition, the standard deviation of per capita GDP (lnPGDP) is 0.638, suggesting marked disparities in regional fiscal capacity and economic development. The average urbanization rate (Urban) is 55.886 %, the standard deviation reaches 13.715, the minimum value is only 22.6 %, and the maximum value reaches 89.85 %, showing that the level of urbanization development between regions in China is significantly different. The average industrial structure (Indus) score is 43.427, and the standard deviation value reaches 9.615, indicating that there is a certain gap in the degree of industrial structure upgrading in various regions. On the whole, each variable shows different degrees of discreteness, reflecting the obvious differences in economic development, financial investment, urbanization level and industrial structure between regions, which provides the basis for subsequent empirical analysis.

Table 3. Results of Descriptive Statistical Analysis

Variable Symbols	Variable Name	Sample size	Mean	Standard Deviation	Minimum value	Maximum value
BPS	Comprehensive Supply Score	1650	0.1906	0.0499	0.0843	0.4543
Shrink	Population Decline	1650	0.283	0.4506	0	1
lnFiscal	Fiscal Expenditures	1650	5.9047	0.7886	3.7615	9.1977
lnPGDP	GDP per capita	1650	10.8174	0.6383	8.8809	12.2881
Urban	Urbanization Rate	1650	55.886	13.7145	22.6	89.85
Indus	Industrial Structure	1645	43.4273	9.6151	20.66	78.23

4.2 Benchmark Regression Results

Population shrinkage has a negative coefficient in all models. This indicates an inverse link with urban basic public service provision. In the absence of control variables and fixed effects, population shrinkage has a coefficient of -1.536. It is statistically significant at the 1 % level, pointing to marked disparities in basic public service supply between shrinking and non-shrinking cities. Once per capita GDP, urbanization rate, and industrial structure are controlled for, the coefficient of population shrinkage variable has decreased, this implies that urban socioeconomic development can explain the difference in the provision of certain basic public services. With city and year fixed effects further controlled for, the coefficient of population shrinkage variable is -0.403, and its significance is confirmed at the 5% level, indicating that after excluding the combined effects of urban individual differences and years, population shrinkage will still have a negative impact on the level of urban basic public service supply. The results are basically consistent with the previous theoretical analysis, which verifies the research hypothesis H1, that is, cities facing population shrinkage will see a decline in basic public service supply. (As shown in Table4)

4.3 Robustness Checks

In order to further test the stability of the benchmark regression results, this study conducts robustness tests from three aspects: lag effect, extreme value processing and special sample

elimination. First, population shrinkage may exert a lagged effect on urban basic public service provision, the core explanatory variable was replaced with its one-period lagged value for re-estimation. Estimation results reveal that the coefficient on the lagged population shrinkage term (L. Shrink) stands at -0.507, significant at the 5 % level, indicating a degree of persistence in the negative impact. Second, to prevent extreme values from distorting the estimation results, all continuous control variables (including the dependent variable, per capita GDP, urbanization rate, and industrial structure) were winsorized at the 1 % level before re-running the regression. The coefficient of the population shrinkage variable is -0.371, significant persists at the 5 % level, In both sign and significance, the coefficients largely mirror the benchmark findings. Third, considering the special administrative status, resource allocation capacity, and foundational public service conditions in directly administered municipalities, this study excludes the samples of Shanghai and Chongqing and re-estimates. The results show that the coefficient of the population shrinkage variable is -0.372, significant at the 5 % level, indicating that the benchmark results do not depend on these particular city samples. Overall, across different robustness check methods, the coefficients of the population shrinkage variable remain negative and statistically significant, confirming that population shrinkage affects urban basic public service supply negatively. The effect is fairly stable. The benchmark findings hold up. (As shown in Table 5)

Table 4. Benchmark Regression Results

Variable	Model 1	Model 2	Model 3	Model 4
Population Decline (Shrink)	-1.5363*** (-0.5158)	-0.1391 (-0.3151)	-0.1643 (-0.1964)	-0.4026** (-0.1858)
Per capita GDP (logarithm)		3.9158*** (-0.7192)	2.7011*** (-0.7832)	-2.8000*** (-0.9572)
Urbanization Rate		0.0731* (-0.0442)	0.1548*** (-0.0555)	0.0543 (-0.0716)
Industrial Structure		0.0005 (-0.0008)	-0.0004*** (-0.0001)	-0.0002** (-0.0001)
Control Variables	No	Yes	Yes	Yes
City Fixed Effects	No	No	Yes	Yes
Fixed-effect for year	No	No	No	Yes
Sample size	1650	1650	1650	1650
R^2	0.0193	0.4754	0.7766	0.8457
Adjusted R^2	0.0187	0.4742	0.7601	0.8328

*Note: The parentheses report robust standard errors clustered by city. *, and *** correspond to significance levels of 10%, 5%, and 1%, respectively.

Table 5. Robustness Check Results

Variable	Baseline Model	One issue behind	1% truncation	Exclude municipalities directly under the central government
Population Decline (Shrink)	-0.4026**		-0.3714**	-0.3720**
	(0.1858)		(0.1769)	(0.1846)
One-Period Lagged population shrinkage (L.Shrink)		-0.5070**		
		(0.2214)		
Per capita GDP (logarithm)	-2.8000***	-2.3611***	-2.6591***	-2.9274***
	(0.9572)	(0.8389)	(0.8603)	(0.9281)
Urbanization Rate	0.0543	0.0718	0.0663	0.0874
	(0.0716)	(0.0822)	(0.0652)	(0.0637)
Industrial Structure	-0.0002**	-0.0001	-0.0387	-0.0002**
	(0.0001)	(0.0001)	(0.0242)	(0.0001)
Control Variables	Yes	Yes	Yes	Yes
City Fixed Effects	Yes	Yes	Yes	Yes
Fixed-effect for year	Yes	Yes	Yes	Yes
Sample size	1650	1540	1650	1620
R^2	0.8457	0.8548	0.8529	0.8377
Adjusted R^2	0.8328	0.8418	0.8406	0.8241

4.4 Mediation Effect Analysis

In the total effect model, the coefficient of population shrinkage on the level of urban basic public service supply is -0.403, which is significant at the 5 % level, indicating that population decline will reduce the supply level. The results of the mediating variable model show that the coefficient of population decline on local general public budget expenditure is -0.032, a result that also reaches the 5% significance threshold and points to a negative effect of population decline on local fiscal expenditure. When local general public budget expenditure enters the model, the coefficient of fiscal expenditure variable is 1.850, at the 5% level of significance, meaning that more local fiscal expenditure helps improve the basic public services supply. At the same time, the coefficient of population contraction variable falls from -0.403 in the total effect model to -0.343, and it is still significant at the 5 % level. This indicates that fiscal expenditure played a partial medating role in the process of population contraction affecting basic public service supply. Further calculation shows that the indirect effect of fiscal expenditure is -0.060, with 14.85% of the

aggregate influence transmitted through mediation. This shows that population decline may first affect local fiscal expenditure, thereby influencing the level of urban basic public service provision. In general, the mediating effect test supports hypothesis H2, namely that population decline may reduce urban basic public service supply by affecting local fiscal expenditure. (As shown in Table6)

Table 6. Mediation Effect Results

Variables	(1) General Effects Model: Y = Public Service Supply Index	(2) Mediator model: M = ln local general public budget expenditures	(3) Direct-effects model: Y = Public Service Supply Index
Population Decline (Shrink)	-0.4026** (-0.1858)	-0.0323** (-0.0143)	-0.3428** (-0.1665)
ln Local General Public Budget Expenditures			1.8500** (-0.72)
Per capita GDP (logarithm)	-2.8000*** (-0.9572)	-0.1142** (-0.057)	-2.5200*** (-0.89)
Urbanization Rate	0.0543 (-0.0716)	0.0008 (-0.0026)	0.051 (-0.069)
Industrial Structure	-0.012** (-0.05)	0.019*** (0.003)	-0.012** (-0.0001)
Control Variables	Yes	Yes	Yes
City Fixed Effects	Yes	Yes	Yes
Fixed-effect for year	Yes	Yes	Yes
Sample size	1650	1650	1650
R^2	0.8457	0.9783	0.851
Adjusted R^2	0.8328	0.9765	0.8385

*Note: Standard errors are provided in parentheses. *, and *** signify significance at the 10%, 5%, and 1% levels, respectively.

4.5 Analysis of Heterogeneity

4.5.1 Categorization according to the upper, Middle, and Lower Reaches of the Yangtze River

To assess regional disparities in how population shrinkage impacts urban basic public service provision, grouped regressions were conducted for the upstream, midstream, and downstream areas of the Yangtze River Economic Belt. The results are shown in Table 7.

Drawing on the regression findings, the coefficient of population shrinkage in the downstream region is -0.219, but it does not pass the significance test. This shows that when the population shrinkage occurs, the impact on the supply level of basic public services in the downstream cities is not obvious. The reason may be related to the higher level of economic development, better industrial base and stronger financial security ability in the downstream areas. Conversely, the downstream area has a comparatively well-developed public service infrastructure, which can somewhat alleviate the consequences of population decline for the supply of essential public services.

Table 7. Regional Heterogeneity Results across the Upper, Middle, and Lower Reaches of the Yangtze River Economic Belt

Variable	Downstream regions	Midstream Region	Upper reaches
Population Decline (Shrink)	-0.2185	-0.4862**	-0.7324***
	-0.1954	-0.2187	-0.2516
Per capita GDP (logarithm)	-1.8421**	-2.3648**	-3.2157***
	-0.8123	-0.9346	-1.1025
Urbanization Rate	0.0624	0.0746	0.0918
	-0.0587	-0.0694	-0.0832
Industrial Structure	-0.0001	-0.0002*	-0.0002**
	-0.0001	-0.0001	-0.0001
Control Variables	Yes	Yes	Yes
City Fixed Effects	Yes	Yes	Yes
Fixed-effect for year	Yes	Yes	Yes
Sample size	615	540	495
R^2	0.8912	0.8064	0.7628
Adjusted R^2	0.8765	0.7813	0.7354

The variable coefficient of population shrinkage in the middle reaches is -0.486, the result is significant at the 0.05 threshold. It implies that demographic decline constrains the delivery of basic public services in the middle reaches. Some cities in the middle reaches are in the process of industrial transformation and population mobility. The financial capacity and public service base are relatively limited. The continuous reduction of population may affect the local fiscal expenditure capacity and the allocation of public service resources, thus affecting the supply level of basic public services.

The coefficient of population shrinkage in the upstream region is -0.732, which is significant at the 1 % level, which meets the 0.01 significance threshold, revealing that essential public service availability in the upstream region is more severely affected by population loss. The economic base of some cities in the upstream region is relatively weak, and the population outflow and financial pressure are more prominent. As populations keep declining, local authorities are increasingly burdened with sustaining essential public service provision, making the consequences of demographic shrinkage more evident.

In general, the way demographic decline affects basic public service provision varies spatially. The specific performance is that the upstream region has a strong impact, followed by the middle reaches, and the downstream region has an impact but not significant. This result verifies the research hypothesis H3. The results are also

consistent with the basic viewpoints of the core-periphery theory, that is, there are differences in resource agglomeration capacity and development basis in different regions. Amid demographic contraction, public service supply is more susceptible to strain in certain midstream and upstream cities.

4.5.2 Grouping by degree of shrinkage

To investigate how population shrinkage heterogeneously affects cities with different shrinkage levels, this study divides shrinking cities into three categories: occasional shrinkage, mild shrinkage and deep shrinkage, and performs regression estimation respectively. The results are presented in Table 8.

Table 8. Heterogeneity Results by Degree of Population Shrinkage

Variable	Occasional Shrinking Cities	Mildly Shrinking Cities	Severely shrinking cities
Population Decline (Shrink)	-0.1268	-0.4587**	-0.8165***
	-0.2215	-0.2034	-0.2762
Per capita GDP (logarithm)	-1.4263	-2.3156**	-3.0842***
	-1.0352	-0.9721	-1.1084
Urbanization Rate	0.0382	0.0675	0.0946
	-0.0764	-0.0712	-0.0865
Industrial Structure	-0.0001	-0.0002*	-0.0003**
	-0.0001	-0.0001	-0.0001
Control Variables	Yes	Yes	Yes
City Fixed Effects	Yes	Yes	Yes
Fixed-effect for year	Yes	Yes	Yes
Sample size	210	345	570
R^2	0.8346	0.7928	0.7465
Adjusted R^2	0.8074	0.7653	0.7182

In occasional shrinking cities, the coefficient of population shrinkage variable is -0.127, but it does not pass the significance test. This shows that the short-term, accidental population decline has not yet had a significant impact on the level of urban basic public service supply. The population decline in such cities may be more manifested in short-term fluctuations. The allocation of public service facilities and fiscal expenditure arrangements usually do not change significantly immediately due to short-term population changes, so their impact is not significant.

In mildly shrinking cities, the coefficient of population shrinkage variable is -0.459, and it is significant at the 5 % level. This shows that after 2-4 years of population shrinkage, the negative impact on the basic public services supply began to appear. With the extension of the duration of population decline, the demand for public service facilities, local fiscal revenue and public service input capacity may be affected, which in turn affects the level of basic public service supply.

In the deep shrinking cities, population shrinkage enters the model with a coefficient of -0.817, significant at the 1% level, indicating that long-term population shrinkage will significantly reduce the level of urban basic public service supply. The population decline in deep shrinking cities lasts for a long time, and local economic development, financial support capacity and public service resource allocation may face greater pressure. Therefore, the impact of population shrinkage on the supply level of basic public services is more obvious.

In general, the effect of population decline on essential public service delivery has a certain degree of accumulation, which is manifested as: the influence of sporadic contraction is not significant, the effect of moderate and profound contraction is significant, and the influence of profound contraction is more pronounced. This shows that the longer the duration of population shrinkage, the more notable the impact upon urban basic public service delivery. From the standpoint of urban developmental phase, short-term population decline may only be a fluctuation in the process of urban development, while sustained population shrinkage may mean that the city enters the stage of adjustment or contraction, and the supply of public services will gradually be affected. The findings are basically consistent with the relevant viewpoints of the urban life cycle theory, and also verify the research hypothesis H4, that is, the impact of population shrinkage on the supply level of urban basic public services has the heterogeneity of shrinkage.

5. Conclusions and Policy Proposals

5.1 Research Conclusions

Contracting populations lead to a pronounced reduction in the supply of municipal public services, indicating that population decline has not reduced the pressure on public service supply. Baseline regression results reveal that, conditional on city and year fixed effects, and other economic and social factors, population shrinkage will still significantly reduce the level of basic public service supply, assuming that H1 is verified. The robustness tests such as one-period lagged explanatory variables, tail reduction and elimination of special samples further show that the conclusion has strong stability. It can be seen that although the population decline will reduce the demand for some public services, education, medical care,

social security and infrastructure services still need to maintain a certain level of supply, and related facilities and staffing are difficult to immediately reduce in the short term. At the same time, changes such as the decrease of students, the aggravation of aging and the more dispersed distribution of population accompanied by the population outflow have also made it more difficult to adjust the publice service supply. Therefore, population shrinkage is not only a problem of reduced demand for public services. How to adjust the public service supply according to changes in population size and spatial distribution is also a problem that shrinking cities need to face.

Fiscal expenditure plays a partial intermediary role in the process of population shrinkage affecting basic public service supply, indicating that population shrinkage affects basic public service supply by affecting local government fiscal expenditure. The test results show that population shrinkage has a significant negative impact on fiscal expenditure. Once fiscal expenditure is added to the model, the coefficient of population shrinkage on basic public service supply becomes smaller, and H2 is supported. This is mainly because the population outflow will reduce urban economic activity and tax revenue, compress the fiscal expenditure space of local governments, and lead to a decrease in the amount of funds available for basic public services. However, basic public services are meant to be guaranteed. The operation and maintenance costs of infrastructure do not fall simply because the population shrinks, so reduced service demand may coexist with financial pressure.

Population decline affects urban public service delivery unevenly across regions and stages, suggesting that cities experiencing demographic shrinkage require context-specific rather than uniform public service governance. In terms of regional disparities, population shrinkage exerts a stronger negative influence on the supply of basic public services in the upper reaches, followed by the midstream area, with no significant effect in the downstream area. This indicates that regions have different capacities to withstand population shrinkage, and Research Hypothesis H3 is confirmed. Some cities in the upstream and midstream regions have relatively limited industrial bases and fiscal sustainability. After population outflow, they are more prone to weakened urban development vitality, which further affects their capacity to improve public services. In contrast, the downstream region has a good economic foundation, strong inter-city links, and a relatively complete public service system, so it can buffer the adverse effects of population shrinkage to a certain extent. From the perspective of the degree of contraction, the influence of occasional contraction on basic public services supply is not significant, both mild and deep contraction have significant effects, and the impact of deep contraction is stronger. This shows that the impact of population shrinkage on the basic public services supply is not immediately apparent in the short term, but has the characteristics of gradual accumulation, and the research hypothesis H4 is verified. The short-term population decline may only be a periodic fluctuation. Only when the contraction continues to occur, problems such as insufficient school students, reduced public transport passenger flow, structural changes in primary health care and pension needs, and reduced operational efficiency of facilities will gradually emerge, and exert a more pronounced effect on basic public service provision. Therefore, we should classify and understand the impact of population shrinkage on the basic public services supply in cities according to the actual situation of different regions and cities with different degrees of shrinkage.

5.2 Policy Proposals

Based on the above research conclusions, under the background of population shrinkage, urban essential public service provision should change the traditional idea of scale expansion, and turn to the bottom line guarantee, precise support and classification adjustment. Therefore, the following recommendations are made:

First of all, strengthen the protection of basic public services, not simply reduce public service investment and facilities. For compulsory education, basic medical care, pension, public transportation and other services related to the basic life of residents. Even if the population declines and demand reduces, the necessary service facilities should be retained. For example, areas with a decreasing school-age population can optimize educational resources through joint school running and school bus transfer; strengthen primary health care and pension services in aging areas; basic services are guaranteed by means of itinerant diagnosis and treatment, bus reservation and so on. In a word,

on the basis of ensuring the basic needs of residents, we should flexibly adjust the service mode and resource allocation, so as to improve the rationality and accessibility of public service supply.

Secondly, financial support should be tilted to severe population shrinkage and greater financial pressure cities. In some cities, the population continues to decrease and the fiscal revenue declines, but the basic services such as schools, hospitals, and old-age care still need to be maintained. The higher-level finance should give the necessary financial support, and the financial input cannot be reduced simultaneously because of the population decline. In addition to considering the population size, the allocation funds should also consider the duration of the population shrinkage, the proportion of the elderly population and the local fiscal revenue capacity, so as to solve the problem of high cost of basic public services. For cities with severe population shrinkage and financial difficulties, priority should be given to the protection of schools, primary medical care, old-age care and social security services; for cities with less population shrinkage but already under financial pressure, facilities with lower utilization rate can be merged and transformed according to actual needs, reduce the cost of repeated construction and maintenance.

Finally, cities with different degrees of shrinkage should adopt different ways of public service adjustment. Cities with occasional population decline can observe population changes, and then slowly adjust according to the actual situation ; slightly shrinking cities can adjust the layout of schools, medical services and other services in time, avoid idle facilities and decline in service quality ; deep shrinking cities can appropriately integrate facilities with low utilization rate under the premise of ensuring the basic living of residents, or improve the utilization rate of facilities by means of one multi-purpose. In addition, the situation in different regions is also different. The shrinking cities in the upper and middle reaches should focus on ensuring basic public services such as education, medical care, and old-age care, avoid further reduction of public services after population outflow and affect residents ' lives. Cities in the lower reaches can use the conditions of metropolitan areas and urban agglomerations to strengthen the sharing of resources between different cities, so that limited public service resources can be more fully utilized. In general, the adjustment of public services should be promoted in stages and according to the degree of urban population change and the actual situation in the local area, instead of blindly adopting a one-size-fits-all approach.

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