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Intercity mobility pattern and settlement intention: evidence from China

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Abstract

Floating population is an important group in the emerging urbanization process. This group promotes long-term settlement, which is a significant driving force increasing the urbanization level of countries. This study analyzed the changes in population mobility between Chinese cities and the willingness of the floating population to settle down. The analyses were based on data obtained from the *China Migrants Dynamic Survey* (CMDS) in 2017, and the China Seventh Census 2020. Spatial econometric models were constructed for in-depth research. The result showed that: ① the floating population migrated mainly from the central region to the surrounding cities, and their long-term settlement intention presented a spatial pattern of "high in the east, low in the west, and local concentration." ②the long-term settlement intention significantly negatively affected the urban floating population. City economic level, public service capacity, and environmental quality significantly positively or negatively influence the number of the floating population. For promoting more floating population to become urban residents, management of the group should be strengthened, construction level of the urban economy, society, and ecology improved, and the willingness of the group to settle for an extended time encouraged.

Keywords: Intercity floating Population, Long-term settlement Intention, Spatial pattern, China seventh census

1 Introduction

The floating labor force is related closely to the future economic and social development of cities and is, therefore, a significant force driving the economic development of a country (de Arce & Mahia, 2013). The large-scale surplus labor force migrating to cities from rural areas provides a solid support for the rapid development of cities (Zhou, 2018). Moreover, urbanization necessitates increased construction to provide more space for living, working, relaxing, studying, and shopping. As indicated by the data obtained from the seventh national population census of China, the floating population in the country had reached 376 million in 2020, an increase of nearly 3.1 times compared with that indicated by the sixth national population census in 2010. Such a large-scale floating population indicates that China is gradually entering an era of rapid flow. Under the background that floating population is becoming a group that can't be ignored in urban development, exploring where they come from, where they live, and what characteristics they have can provide inspiration for predicting the future population size of cities. On this basis, cities can implement the equalization of basic public services according to local conditions, promote the citizenization of floating population, and enable floating population to be willing to enter the city, and be willing to live and develop in the city for a long time.

Population migration in China, influenced by the early registered residence system, is divided into two processes, namely population migration and settlement. Traditional studies mainly focused on the phenomenon of population migration. However, in view of people-centered urbanization rather than things or land-centered urbanization, promoting the continuous modernization development of city is achieved only by encouraging more floating people to settle and become long-term

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inhabitants of cities. Accordingly, it is considered important to analyze the current floating population in China and their settlement intention.

The floating population would choose to settle in cities only when such cities meet their needs of higher wage levels, comfortable environment, harmonious social atmosphere, convenient public service facilities, and the like. The willingness of the floating population to settle down reflects whether they are prepared to live in a city for an extended time as a migrant population. This aspect also indirectly reflects the benefits received from the city. Some members of the floating population are only temporary urban residents, choosing not to settle down in the in-migration area for a long time. However, an excessive floating population gives rise to a series of social problems in cities, such as excessive population growth and employment pressure (Liang, 2011), which not only affect the interests of permanent residents but also hinder the process of urbanization. Therefore, understanding the changes in urban population mobility and the settlement intention against the background of the modern migration in China, we need to treat the issue of floating population with a more rational, objective, comprehensive and rigorous attitude and perspective. Relevant political, economic and social systems shall be formulated according to the specific situation of the floating population in the city, so as to ensure that the floating population can enjoy fair opportunities for medical treatment, employment, schooling, etc. in the inflow place, and avoid problems such as housing tension, traffic congestion, environmental pollution, and social conflicts caused by excessive urban population. Then we can manage the urban floating population more effectively and scientifically to ensure the normal operation of the city.

The purpose of this study was to address the research gaps by updating data from the *China Migrants Dynamic Survey* (CMDS; 2017) for further analyzing the spatial characteristics of population mobility between cities and the settlement intention of the floating population, based on individual micro settlement intention. Combined with the latest data of the seventh national census, the research was the first to unveil the relationship between settlement intention and floating population by constructing spatial econometric models, and thus provide new enlightenment for scholars and managers to manage the floating population.

The rest of this manuscript is arranged as follows. In Sect. 2, we present a review of the relevant literature on the floating population and their willingness to settle down. Our research ideas, data, and models are introduced in Sect. 3. The analyses of the spatial characteristics of the urban floating population and their settlement intention are presented in Sect. 4. In Sect. 5, we further discuss the impact of long-term settlement intention on intercity floating population. A summary of the research findings is given in Sect. 6, and we present various policy suggestions.

2 The spatial pattern of floating population and its influencing factors

Ravenstein (1885) presented seven laws of population migration and observed that factors such as economy, urban–rural differences, distance, migration stage, transportation facilities, gender and age can affect population migration. Since then, the academic community has conducted extensive research on population migration. According to Herberle (1938), population migration is affected by forces in two directions, namely push and pull, which coexist in places of population outflow and inflow. This theory has since been improved or revised continually by other scholars (Lee, 1966). Lewis (1954) proposed a new interpretation model of population migration from the perspective of the gap between urban and rural areas. Cities are dominated by the development of advanced industrial sectors, whereas rural areas are dominated by agricultural sectors with low labor productivity. The wage gap between urban and rural areas drives the labor force from rural areas to cities until a balance is reached between these urban and rural areas. Similarly, Todaro (1969) believed that the expected income gap between urban and rural areas drives the flow of surplus rural labor to cities.

Numerous factors influence population migration. From the perspective of traditional economics, urban house prices (Plantinga et al., 2013), financial situation (Chakraborty and Garg 2019), income inequality (Stark 2005), and other factors influence such migration. The social and environmental factors that influence population migration have also been explored. For instance, Glaeser et al. (2001) found that urban infrastructure, such as urban transportation and public services, is related closely to migration. According to Ciarniene and Kumpikaite (2011), other social factors, such as education, language, employment opportunities, social environment, and politics also affect the relocation decisions of migrants. In terms of environmental issues, include environmental calamities, hardships, amenities, barriers and their management also have promoted migration flow to other places (Gutmann and Field 2010).

In China, the long-standing special registered residence system has had a pronounced effect on population mobility. As pointed out by Gu et al. (2022), in attempting to solve the disadvantages of the system, the government has promoted reforms in recent years and has gradually relaxed the restrictions on urban registered residence. However, the effects of the registered residence

system on the benefit of public services and the social integration of the floating population cannot be ignored. Considering that the settlement decision of the floating population significantly affects the level of urbanization, several scholars have focused on analyzing the factors that affect the settlement intention. From the external macro perspective, urban factors such as urban economic development (Chen & Liu, 2016; Chen et al., 2020), urban scale (Dang et al., 2019; Song et al., 2022), and air pollution (Zhao et al. 2021) significantly affect the settlement intention of the floating population. Gu et al., (2021a, 2021b) attributed the willingness to settle down to internal driving factors, such as individual wages, marriage and number of family members, as well as urban external constraints, such as urban economy, public service provision, and urban ecology. Micro individual factors also influence the settlement decision, such as age (Liu et al., 2018; Yue et al., 2010), gender (Yu et al., 2020), physical and mental health (Huang et al., 2020), social relations (Huang et al., 2018), and education level (Liu et al., 2018).

Starting from the spatial differentiation characteristics of the willingness to settle down, Gu et al. (2020) analyzed the willingness of migrant workers to move their registered residence from the provincial level of China. The results showed a significant network autocorrelation in the willingness network, with the willingness to move the registered residence from underdeveloped to developed cities being higher. Gu et al. (2018) used CMDS (2015) data to analyze the spatial difference in the settlement intention and found not only significant autocorrelation in space but also a spatial pattern of "high in the north and low in the south, and U-shaped in the east and west." Gu et al., (2021a, 2021b) explored the network characteristics of the settlement intention of the floating population between cities, finding higher intention to move from low-level cities and settle in developed cities. At the municipal level, cities can be divided into different spatial nodes or communities according to the settlement intention network of the floating population. As regards specific floating population groups, Li and Xie (2020) analyzed the interprovincial mobility of youth groups in the floating population using CMDS (2017) data. Liu et al. (2021) explored the spatial mobility characteristics of the new generation of floating population.

Although extensive research and in-depth discussion have been conducted on the floating population and their willingness to settle down, there are still many aspects that have not been analyzed. The willingness to settle, in particular, is key to increasing urbanization in China and, therefore, must be included in relevant systematic analysis. However, the spatial trend analysis of willingness to remain is inadequate. Research on the influencing factors of settlement intention focuses mainly on external factors, and few studies consider such intention as a factor to analyze whether the index would affect other floating population variables. Therefore, we aimed to further analyze the spatial pattern of China's floating population and the settlement intention of the group, as well as whether the settlement intention three years before would affect the scale of the urban floating population. Our analyses results could provide a decision-making reference for population managers and institutions.

3 Research framework and data description

3.1 Research framework and methods

3.1.1 Spatial autocorrelation analysis

Spatial autocorrelation is a common phenomenon in spatial data, and Moran's I is a statistical index widely used to identify spatial autocorrelation. The global spatial correlation analysis uses the global Moran's I (GMI) to analyze whether all spatial units have spatial spillover effects. We uses this index to analyze whether there is a significant spatial autocorrelation feature in the net migration rate of floating population. The formula is as follows:

$$GMI = \frac{n}{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}} \frac{\sum_{i=1}^{n}\sum_{j=1}^{n}(x_i - \overline{x})(x_j - \overline{x})}{\sum_{n=1}^{n}(x_i - \overline{x})^2} \tag{1}$$

where i and j represent spatial units, x_i and x_j is the observed value of space unit i and j respectively, $\overline{x}$ is the mean of observations, and w_{ij} is the spatial weight matrix. When spatial element i is adjacent to j, w_{ij} value is 1; Otherwise, the value is 0.

In addition, the local spatial correlation analysis can be used to examine the degree of association between a spatial element and its adjacent elements. The formula of the local Moran's I is as follows:

$$LMI = \frac{n(x_i - \overline{x})\sum_{i=1}^{n} w_{ij}(x_j - \overline{x})}{\sum_{n=1}^{n}(x_i - \overline{x})^2} \tag{2}$$

When LMI is positive, it indicates that an area is associated with the surrounding area in a "high-high" or "low-low" way; When LMI is negative, it means that an area is associated with the surrounding area in a "high-low" or "low–high" way.

3.1.2 Spatial econometric model

The traditional linear regression model mainly uses the ordinary least squares (OLS). However, for spatial data with strong spatial autocorrelation, the results of OLS may not be accurate. While the spatial econometric models can better identify the interrelation between regions. Therefore, we use the spatial econometric model to analyze the impact of settlement intention on the number of floating population in China seventh census, and

construct a spatial lag model (SLM) and a spatial error model (SEM). And SLM mainly discusses whether the explained variable has spillover effect, that is, spatial lag. The expression is shown in formula (3). While the SEM adds the lag term of the random error term, taking into account the spatial correlation of the missing variables that can affect the dependent variables. The expression is shown informula (4).

$$Y = \rho W_y + \beta X + \varepsilon \tag{3}$$

$$Y = \beta X + \varepsilon, \varepsilon = W_\varepsilon + \mu \tag{4}$$

where: Y is the dependent variable, X is the matrix of independent variables with the $n \times k$ form, ρ is the spatial regression coefficient, β indicates the influence of X on Y, W_y is the spatial lag dependent variable of spatial weight matrix W, W_ε is the error lag term, ε and μ represents a random error term.

3.2 Research data

Vrious factors influence the floating population, including politics, economy, society, culture, and the like. We regarded the settlement intention as one of the influencing factors on the number of the floating population, while tried to find other influencing factors from the aspects of economic level, society, environment, etc.. We regarded the number of the urban floating population in the seventh national census (2020) as the dependent variable and the willingness to settle for a long duration (over five years) in 2017 as the core explanatory variable. At the same time, economic level, public service, and environmental quality were added as control variables. Economic level includes per capita gross domestic product (GDP), industrial structure, and financial level. Public services include the level of medical care and education. Environmental quality includes green space ratio and air quality. The relevant indicators and descriptions are shown in Table 1. Prior to constructing the model, we conducted a multi-collinearity test on the variables, which indicated that the variance inflation factor (VIF) of each variable was less than 5, implying light multi-collinearity.

The data were source was the CMDS (2017) and we adopted stratified, probability proportional to size (PPS), and multi-stage sampling methods to obtain subsamples. The survey objects included population of 15 years of age or older, people staying in the locality for more than one month in 31 provinces, municipalities under direct central government control, autonomous regions, and the Xinjiang Production and Construction Corps. The Xinjiang Production and Construction Corps, also known as XPCC or Bingtuan, is a unique state-owned economic and paramilitary organization under the dual leadership of the central government and the Xinjiang Uyghur Autonomous Region of China. The XPCC has administrative authority over several medium-sized cities, as well as settlements and farms in Xinjiang. A total of 169 000 sampling data were collected. The research indicators included the current residence of the floating population, the original registered residence, long-term settlement intention and others. As the research object is the intercity floating population, we selected the individuals who are "interprovincial" and "intercity within the province" according to the answer to "the scope of this migration" in the questionnaire. Then, individuals who answered "no" or “undecided” to the question, "do you intend to stay here for some time in the future?" were excluded from the sample population. and reorganize the data. After rearranging the data, 79 746 valid sample data were finally obtained. The number of the floating population was derived from the *Tabulation on 2020 Cina Population Census by County*, and the control variables from the *China City Statistical Yearbook (2021)*. After matching

Table 1 Selection and description of indicators

Variable type	Variables	Symbol	Variable interpretation
Dependent variable	Floating population	population	Population with registered residence in other towns or streets
Core independent variable	Long-term settlement intention	rate	Proportion of urban floating population expected to stay for the next five years or longer
Economic level	Per capita GDP	lnave_GDP	The reciprocal of per capita GDP
	Industrial structure	industry	Proportion of tertiary industry output value in regional GDP
	Financial level	finance	Local general public budget revenue
Public service	Medical level	hospital	Number of hospital beds
	Educational level	education	Proportion of education expenditure in local general public budget expenditure
	Teacher level	teacher	Number of full-time teachers in colleges and universities
Environmental quality	Green space ratio	green	Green area ratio of built-up area
	Air quality	air	Annual average concentration of inhalable fine particles

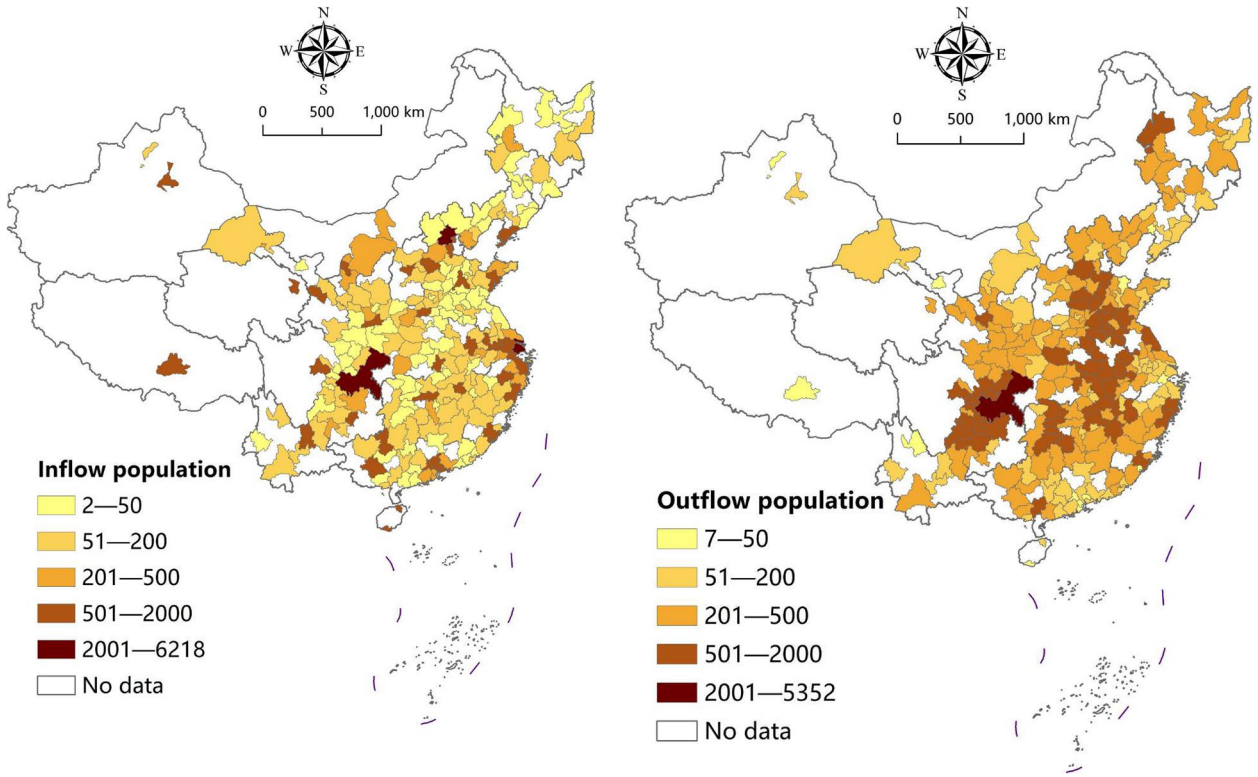

Fig. 1 In-migration and out-migration of the floating population in China. Data source: *China Migrants Dynamic Survey* (CMDS; 2017)

CMDS data with cities, specific data of 226 cities are finally obtained.

4 Spatial characteristics of urban floating population and settlement intention

4.1 Urban population mobility

4.1.1 Population inflow and outflow in cities across the country

Generally, the phenomenon of population outflow from economically underdeveloped areas is obvious, while the earlier economic development of coastal cities leads to higher economic development, more employment opportunities and better living conditions compared with inland areas, which can attract more floating population from inland areas. As shown in Fig. 1, the relocation of the floating population are mainly concentrated in Beijing, Shanghai, Guangzhou, Shenzhen, and other provincial capitals, which can provide better living, employment, study and other conditions, whereas outflow is mainly from cities in Central China, such as Sichuan, Hunan, and Hubei provinces. This finding reflected that numerous people leave their economically disadvantaged hometowns, enter large cities to work or study, or leave their registered residence for other reasons. However, we found that several cities in the west of China also have numerous migrants, probably related to the *13th Five-year Plan for Western Development* issued and implemented by the State Council in January 2017. The aim of strengthening the construction of the western region from the national level was to narrow regional development differences, promote sustainable socioeconomic development, and attain an all-round moderately prosperous society. Achieving this aim implies that more people are required to relocate to the western region.

The network analysis method of "origin and destination "(O-D) by Ding et al. (2021) was employed in this study to show the spatial pattern of population mobility. We constructed the O-D population migration network, taking the former registered residence of the floating population as the starting point and the current city of residence as the destination. We set the threshold value of the number of sample flows at 10, eliminated the number of samples below this threshold in each migration flow and, finally, obtained the migration route and intensity of the floating population, as shown in Fig. 2. The figure indicates that Beijing, Shanghai, Shenzhen, and other cities considerably attract population. The floating population mainly migrates from the central region to surrounding cities, initially showing an urban 'diamond' pattern. The main nodes are the Pearl River Delta, Yangtze River Delta, Chengdu–Chongqing region,

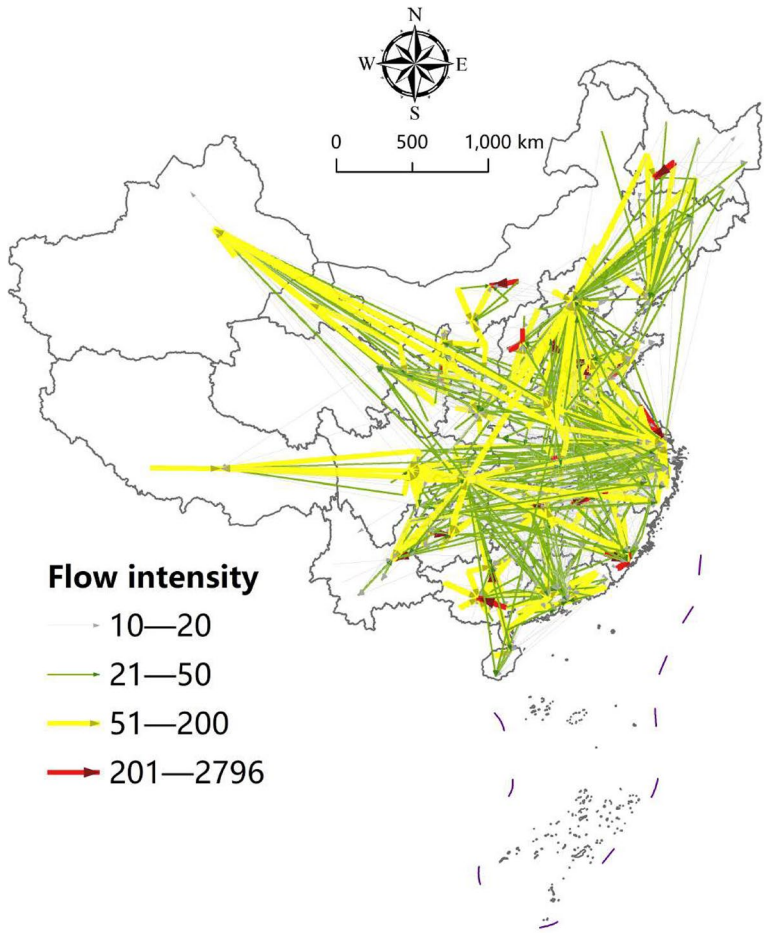

Fig. 2 Migration route and intensity of floating population. Data source: *China Migrants Dynamic Survey* (CMDS; 2017)

Yangtze River Economic Belt, and important cities around the Bohai Sea (Chen & Xu, 2019). The eastern coastal areas show a more obvious urban network system compared with that in the inland areas, such as the Xinjiang and Tibet provinces. The flow of people between these eastern cities is more active, attributed to the higher level of economic advantages and closer economic cooperation between the regions.

4.1.2 Spatial pattern of urban net inflow

We reviewed the methods proposed by predecessors in our comprehensive consideration of the final effect of the inflow and outflow of people to calculate the net migration rate of population in each city (Li and Xie 2020). As the survey data of the floating population were employed, the total number of survey samples in each city was used as the total population of the region. The calculation formula for net migration rate is as follows:

$$\text{Net population mobility} = \frac{\text{Inflow} - \text{outflow}}{\text{Total number of urban survey samples}}$$

The net population migration rate reflects the mechanical growth in population brought about by the floating population of each city to the region over a period of time, as well as the final direction of population flow in the city (Li et al, 2014). Figure 3 shows the spatial pattern of the net migration rate of various cities in 2017, with the net increase in the floating population being concentrated mainly in the eastern and southern coastal cities. The net migration rate in most of the central region is negative, implying significant population loss in the central region. On the whole, the net migration rate of China's population mobility shows a pattern of "low in the middle, high around". This spatial difference indicates that compared with the decreasing trend of the population in the central region, the population in the surrounding areas is mainly increasing.

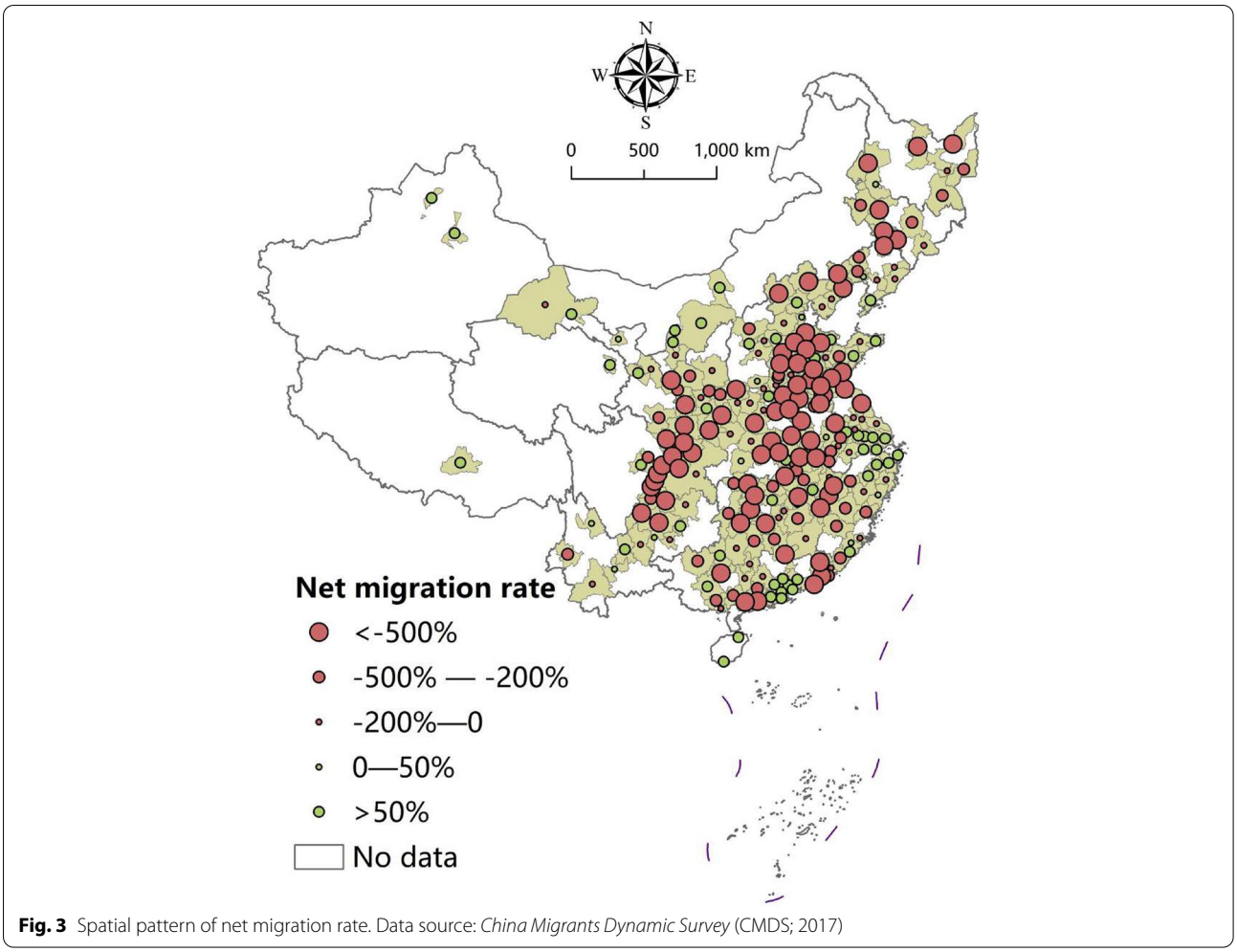

Fig. 3 Spatial pattern of net migration rate. Data source: *China Migrants Dynamic Survey* (CMDS; 2017)

4.1.3 Urban net inflow

To explored whether the willingness of the floating population to settle presented an aggregation phenomenon in space, we calculated the global Moran's I of settlement intention, the value of which is 0.069, and the p value is 0.001. This indicated that the net mobility did show a spatial aggregation phenomenon. To further analyze the type of spatial aggregation, We drew the Local Spatial Autocorrelation Changes (LISA) aggregation diagram of the net migration rate in each city according to the local Moran's I (Fig. 4). As shown in the figure, the local Moran's I of most cities in China is not significant. This finding implied that the net migration rate of floating population in a city is high, but this city is unable to make surrounding cities to attract more floating population. However, we observed that the local Moran's I results in some cities in the central region of the country are "low-low," implying low net mobility, with the net mobility of surrounding cities also being low. A low urban net migration rate could lead to the migration rate of the surrounding urban population also being low, which could be related to people's psychological tendency. When the economic development of a city is poor, the development of the region is often relatively sluggish and limited, which, obviously, affects the willingness to relocate to the place.

4.2 Spatial characteristics of urban long-term settlement intention

4.2.1 General layout of settlement intention intensity

Based on the preceding discussion of the number of the floating population, the next step was to analyze the quality of population mobility, i.e., the willingness to settle. Based on the questionnaire data of the CMDS, the answer to the question, "if you intend to stay here, how long do you expect to stay here" is defined as long-term settlement intention (more than five years). This information was used to calculate the proportion of the sampled population willing to live for a long duration in each city, after which the kernel density map of settlement

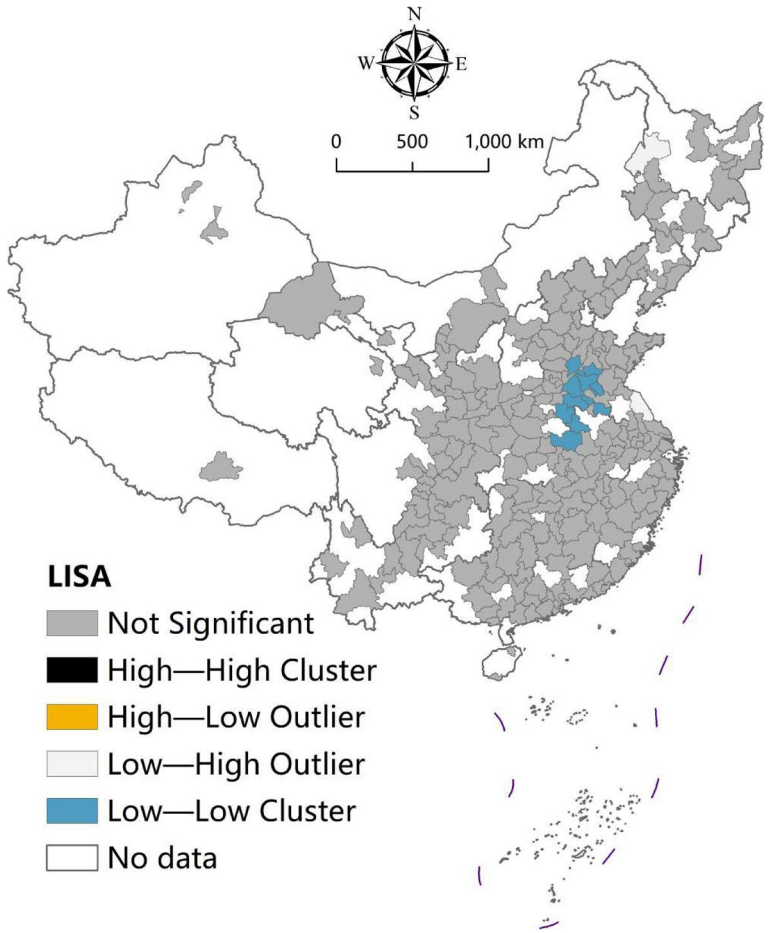

Fig. 4 LISA aggregation diagram of the net migration rate. Data source: *China Migrants Dynamic Survey* (CMDS; 2017)

intention was constructed (Fig. 5). The areas with high willingness to settle are concentrated mainly in the Beijing–Tianjin–Hebei area, central and southern Liaoning city clusters, the Yangtze River economic belt, Pearl River Delta, and other places with significant economic development. At the national scale, the intensity of long-term settlement intention shows a trend of "strong in the east and weak in the west, and regional concentration." This finding reflected that regional integration development in China has, indeed, attracted more floating population to move in and settle down, with the regional radiation driving effect also being evident. Differing from the net migration rate, the proportion of settlement intention reflects that the high settlement intention in central cities could drive a corresponding increase in the settlement intention in surrounding cities.

4.2.2 Settlement intention flow at different levels

Referring to the method proposed by Ding et al. (2021), the settlement intention of the populations of the cities was divided into four levels by employing the natural breakpoint method of ArcGIS (Esri, USA). These levels are relatively low long-term settlement willingness flow (settlement intention $\leq 30.00\%$), low long-term settlement willingness flow ($30.00\% <$ settlement intention $\leq 50.41\%$), medium long-term settlement willingness flow ($50.41\% <$ settlement intention $\leq 68.18\%$), and high long-term settlement willingness flow (settlement intention $> 68.18\%$). Figure 6 shows the visualized flow direction of settlement intention at different levels.

The relatively low settlement intention flows and the low settlement intention flows are mainly from the mainland to coastal cities, concentrated particularly in the Pearl River Delta, Yangtze River Delta, Beijing–Tianjin–Hebei, and other urban agglomerations. These two types of settlement intention flows usually span extended spatiotemporal range. A reasonable explanation is that the floating populations in the central and western regions migrate to coastal cities with relatively good resources over a long distance for temporary work or to

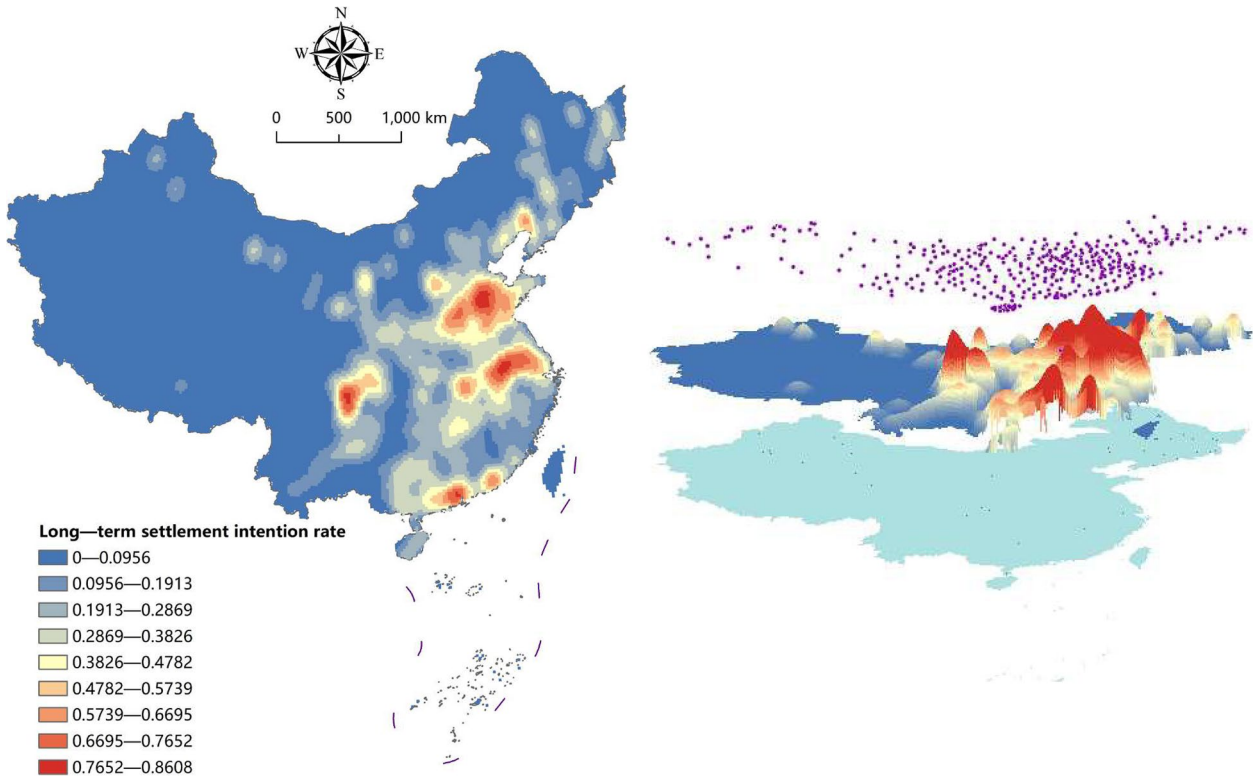

Fig. 5 Kernel density of settlement intention. Data source: *China Migrants Dynamic Survey* (CMDS; 2017)

attend school. The medium and high settlement intention flows are far lower in terms of intensity, as reflected in the flow density. However, in comparison, the span of the spatiotemporal range of medium and high settlement intention flow is shorter, indicating that the floating population is more inclined to live in the surrounding developed cities for a long duration. The inflow places of medium and high settlement intention flow are distributed more to the edges and nodes of the diamond urban structure, confirming that this urban network structure is formed by the floating population with stronger settlement intention. These people reside longer and have a stronger intention to stay, thereby contributing to the socioeconomic value of cities.

4.2.3 Population mobility and willingness to settle

All the sampled cities were designated as "low-low," "low–high," "high-low," and "high-high," according to the net migration rate of the urban population and the settlement willingness rate of the floating population (Fig. 7). The net migration rate of most cities was higher than the average value, indicating that some cities with considerable population outflow have reduced their overall net migration rate. In the sample indicated "high willingness to settle–high net migration rate", the representative cities were Beijing, Shanghai, Chongqing, and Chengdu. This result showed that these cities not only have remarkable attraction for population migration but also have a superior urban economic and social environment to attract the floating population to live for a long duration, implying that such cities have higher urban vitality in the short term. The sample cities represented by Wenzhou, Guangzhou, and Shenzhen with "low settlement intention rate–high net migration rate" have a large inflow of migrant population, but the long-term settlement intention of the floating population is not high. These cities have more migrant workers who stay only for a short time because of work or life requirements. The floating population does not have a substantial effect on the permanent population in these types of cites; however, the short-term population growth brought about by the floating population must be considered in the allocation of various urban public facilities. "low-low" cities, such as Suzhou, Yiyang and Hengshui, have to contend with the problem of large population outflow and low population willingness to settle, implying long-term continuous outflow of the urban population and subpar urban development. In cities with "high settlement intention

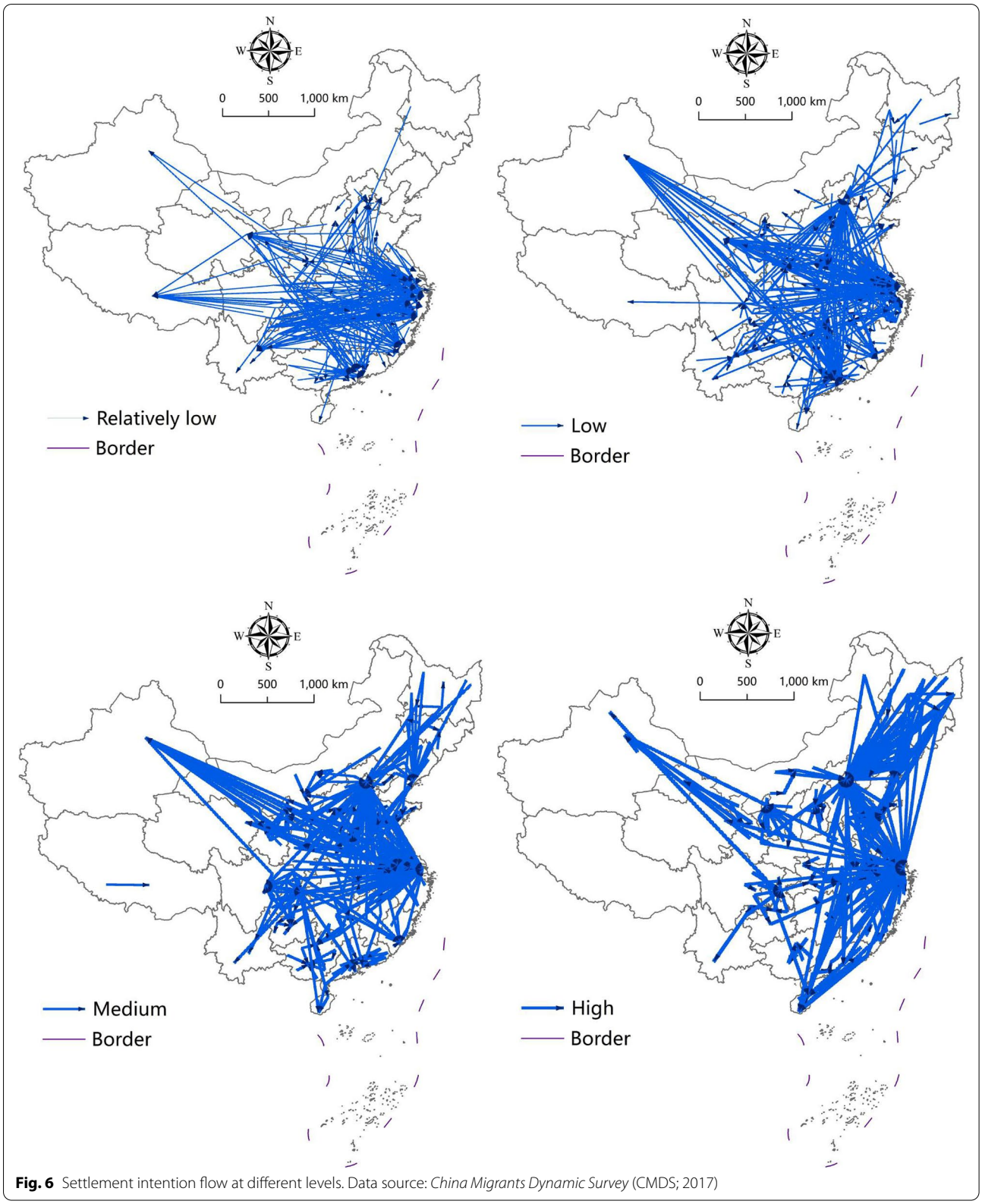

Fig. 6 Settlement intention flow at different levels. Data source: *China Migrants Dynamic Survey* (CMDS; 2017)

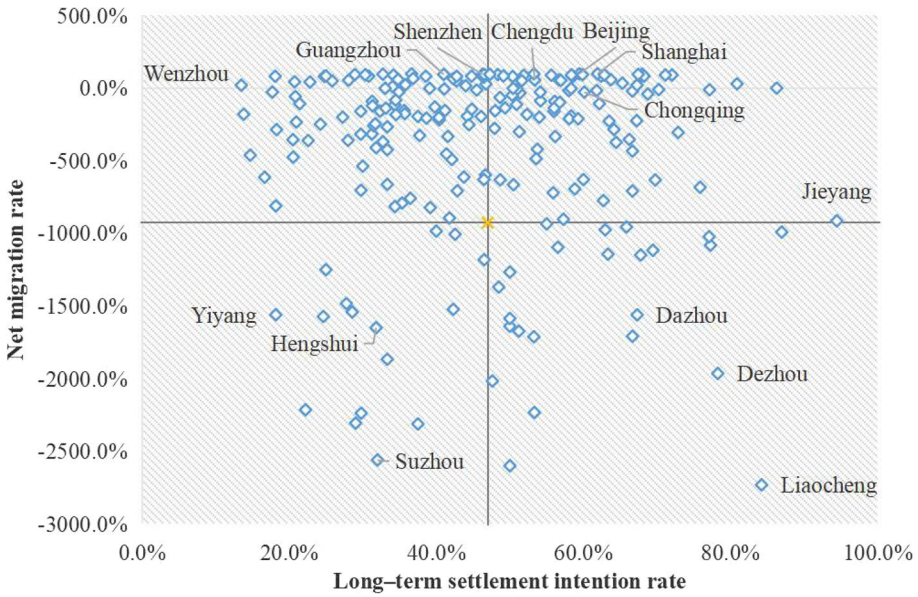

Fig. 7 Four-quadrant diagram of long-term settlement willingness rate and net migration rate. Data source: *China Migrants Dynamic Survey* (CMDS; 2017)

Table 2 Spatial diagnostic test

TEST	statistic	p-value
Moran's I	26.276	0.000
LM-lag	5.500	0.019
Robust LM-lag	0.049	0.825
LM-error	36.260	0.000
Robust LM-error	30.809	0.000

Table 3 Regression results of urban floating population

Variables	OLS	SLM	SEM
rate	-35.280*	-44.370**	-46.670**
	(-20.260)	(-19.690)	(-19.980)
lnave_gdp	38.870***	40.780***	41.070***
	(-13.430)	(-13.270)	(-13.480)
industry	1.377**	1.351**	1.311**
	(-0.622)	(-0.620)	(-0.634)
finance	1.39e-05***	1.39e-05***	1.40e-05***
	(0.000)	(0.000)	(0.000)
teacher	0.002	0.002	0.002
	(-0.002)	(-0.002)	(-0.002)
education	289.000*	273.100	251.400
	(-170.100)	(-168.200)	(-166.300)
hospital	2.06e-03***	2.10e-03***	2.10e-03***
	(-0.001)	(-0.001)	(-0.001)
green	-0.578	-0.461	-0.445
	(-0.694)	(-0.674)	(-0.654)
air	-1.353***	-1.196***	-1.025***
	(-0.341)	(-0.345)	(-0.349)
constant	-424.200***	-466.800***	-485.100***
	(-154.500)	(-155.800)	(-158.700)
ρ		6.34e-07	
sigma		66.890***	66.710***
λ			-2.49e-07*
Log L	-1271.132	-1270.586	-1296.947
N	226	226	226

*** P < 0.01, ** P < 0.05, * P < 0.1, in brackets are robust standard errors

Data Source: CMDS (2017), *Tabulation on 2020 Cina Population Census by County*, *China City Statistical Yearbook* (2021)

rate–low net migration rate," such as Dazhou, Dezhou and Liaocheng, although the population has high settlement intention, the phenomenon of population outflow remains quite serious. These cities need to activate internal employment, industries, and resources, improve their own development level, and retain more residents.

5 Discussion

5.1 Testing of spatial econometric models

In this study, the traditional linear regression model and spatial econometric model were established to select the more appropriate model through comparison. Spatial econometric model has two common models, SLM and SEM, so it is necessary to test the regression model before analysis. Table 2 reports the model selection diagnosis results. We found that the Moran's I was 26.276 and passed the 1% significance level test. This demonstrated that the floating population has significant spatial correlation and spatial aggregation characteristics, and the

spatial econometric model is more appropriate than OLS. In addition, LM-lag and LM-error rejected the original hypothesis at 5% and 1% significance levels respectively. However, in the robust form of test statistics, only Robust LM-error is significant at the level of 1%. Therefore, this study finally used the SEM as the main model to analyze the impact mechanism of the floating population.

5.2 Analysis of spatial econometric model results

According to Table3, it can be found that the coefficient between the core explanatory variable long-term settlement intention and the number of floating population is significantly negative, indicating that the higher the proportion of floating population willing to settle for a long duration, the lower would be the number of floating population in the city in the long term. The time span is three years (2017–2020). As the proportion of the floating population willing to live for over five years was used in this study to measure the long-term settlement intention, this factor partially explains the effect of the long-term settlement intention indicated in 2017 on the number of the floating population lagging behind in 2020. The floating population willing to live in the city for a long time would also be more inclined to settle down locally, enjoy increasing social welfare, which is reflected in the decline in the number of the urban floating population over the long term.

5.2.1 Effect of economic level and public service capacity on urban floating population

Generally, in terms of economic level, the higher the level of economic development of a city, the higher would be the industrial economic structure, per capita income, and employment opportunities available. These factors undeniably attract people living in underdeveloped areas, with increased floating population gathering in the city. The regression results showed that the urban per capita GDP, proportion of the tertiary industry, and local general public budget income have a significant positive effect on the number of the urban floating population. This finding is consistent with the results of previous studies (Yang et al., 2017; Zhang & Leng, 2022). From the perspective of social services, the higher the urban service level for medical treatment, the higher the number of floating population in the city. Because the number of hospital beds is considered to reflect the ability of medical services, and high-level medical services provide assurance and convenience for disease diagnosis and treatment. But at the same time, the level of education and teachers did not have a positive impact on the number of floating population. This may be due to the fact that migrants mainly consider personal prospects, urban economic benefits and other aspects when moving.

5.2.2 Effect of environmental quality on urban floating population

The urban living environment has a specific effect on the choice of the target city by the floating population. Cities with more green space, less air pollution, and advanced wastewater and waste treatment facilities are considered relatively more comfortable and livable, and attract floating population. The results showed that the annual average concentration of inhalable fine particles has a significant negative effect on attracting the floating population, which is consistent with the actual situation. While the coefficient of green space ratio is not significant. This may be because compared with green space, urban air quality can directly affect the daily life of residents.

6 Conclusions

According to the above research on the pattern and settlement intention of the floating population in 2017, economically developed regions are considered to have advantages in terms of both the net migration rate and the long-term settlement intention of the floating population. This finding shows that the attraction of cities for the floating population remains inseparable from the construction of a city's own socioeconomic environment. Therefore, a diamond-shaped network population mobility pattern appears. Developed cities not only attract the population of surrounding small cities but also have more competitiveness of population attraction among large cities. Future changes in the urban floating population can be inferred from the settlement willingness of the floating population. If a city aims to reduce the number of floating population in the future, it must improve the current long-term settlement willingness of this population and attract in-coming population to live locally for a long duration.

Our research provides a new insight into the reasons for the change of floating population. Different from the external factors such as the current urban economic level, public services and environmental quality, the willingness to settle reflects the floating population's own living decision or tendency, which is more microscopic and subjective, and may have a long-term impact on the floating population. This means that if the local government wants to control the number of floating population in the future, the floating population's long-term settlement will also be a factor that can't be ignored.

This research has a specific impact on urban policy. In the context of new urbanization construction, urban governments have to promote and encourage long-term

settlement of the migrant population to maintain this driving force for continuous improvement of the urbanization level. Regardless of whether cities experience net population outflow or net inflow, several crucial measures need to be implemented. These include strengthening the urban construction economy, society, and ecology; enhancing the vitality of economic and industrial development; improving social and public services; promoting the construction of cities suitable for living, working, raising children, traveling, and learning; and, from the perspective of urban internal development and construction, providing internal conditions for attracting the floating population to live for a long duration.

A significant regional imbalance in the willingness of the floating population of China to settle causes further widening of the development gap between developed and undeveloped cities. Attracting more floating population directly influences improvements in the urban economic level of already developed areas, whereas less developed cities have weaker population attraction owing to their inherent lack of economic competitiveness. Local governments should improve the environment, paying attention to the floating population in the city. Further, the developed cities should promote citizenization of the inflow population by introducing preferential incentive policies, maximize their existing advantages for living, environment, and industrial production. It is crucial to attract population inflow in the underdeveloped areas. To achieve this goal, industrial cooperation with surrounding developed cities must be strengthened, economic construction capacity improved, and more employment opportunities created to attract the incoming population. In addition, talented people should be encouraged to return home and start businesses, for which adequate development space must be provided and preferential policies for entrepreneurship and employment implemented.

This study did have some limitations. The first limitation was the lack of availability of recent data. Cross-sectional data of 2017 were used in this study. To enhance understanding of the current situation or the trend in population mobility, the research data need to be updated and compared longitudinally with multi-year data. Secondly, numerous factors affect the scale of the floating population, which are difficult to include comprehensively. The control variables in the current model included only the economic level, public service, and environmental quality. Other variables should be added to support the results of the simulation models in future research, for example, policies, employment, housing prices and transportation.

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Fenghua Wen: research design, conceptualization and funding acquisition. Yating Jiang: writing – original draft, writing – review & editing, validation, analysis and software. Ling Jiang: data resources, manuscript guidance and formal editing.

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Code availability
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Declarations

Competing interests
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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