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Spatial Pattern of Long-term Residence in the Urban Floating Population of China and its Influencing Factors

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Abstract: Exploring long-term residence among the urban floating population is crucial to understanding urban growth in China, particularly since the 2008 financial crisis. By using China Migrants Dynamic Survey data for 2012–2014, China Labor-force Dynamics Survey data for 2014–2016, and macroscale urban matched data, we analyzed the spatial pattern of long-term residential behavior in China's urban floating population in 2012–2016 and developed an urban spatial utility equilibrium model containing 'macro' urban factors and 'micro' individual and household factors to explain the pattern. The results first revealed that long-term residence is defined as ≥ 6 yr for the urban floating population in China. Second, members of this population are more likely to be long-term residents of the megacities in the three urban agglomerations in eastern China as well as of small and medium-sized cities in western and northeastern China, whereas short-term residence is more likely in cities in central China and near the three urban agglomerations. Third, urban population density and housing prices, both have a significant U-shaped effect, are main factors affecting the spatial pattern of long-term residence.

Keywords: long-term residence; urban floating population; spatial pattern; spatial utility equilibrium model; China

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1 Introduction

In the post-financial-crisis era, during which the Lewis turning point has been reached and demographic dividends have disappeared (Cai, 2010), urbanization in China has entered a stage of high costs and balanced welfare (Li, 2012). Consequently, the conventional trajectory of the floating population—from central and western China to the coastal areas—is changing. Moreover, large-scale 'labor reflow' is occurring in central and western cities, causing the populations and economies of some coastal cities to shrink (Li et al., 2017). Therefore, understanding urban population growth in China has become a core task for economists. In view of the relatively stable growth of the urban population at a predictable level of fertility, this paper investigates the growth of the urban floating population and the long-term residence of this population.

Although studies have explored the long-term residence of China's urban floating population (Liu and Xu, 2017), they have focused on long-term residence intention rather than long-term residential behavior because large-scale survey data of urban floating population are difficult to acquire. In fact, intentions of long-term res-

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idence differ considerably from actual settlement behavior in the urban floating population (Zhu and Chen, 2010). Therefore, obtaining long-term data to investigate the long-term residential behavior of the urban migrant population is difficult.

Fortunately, the long-term residence of the urban floating population can be explored using data in the China Migrants Dynamic Survey (CMDS) that are collected by the China Health Planning Commission; these data have large-sample characteristics and reflect the movement of the urban floating population. Additionally, the China Labor-force Dynamics Survey (CLDS) conducted by Sun Yat-sen University reflects the long-term residential behavior of the urban floating population and enables its study. One study evaluated spatial differences in long-term residence of the urban floating population and revealed that eastern coastal China was the core long-term residential area of this population (Yu, 2012). However, since the 2008 financial crisis, the external impetus and internal attraction of urban development have changed. Therefore, the spatial pattern of long-term residence of the urban floating population and its mechanism in the post-financial-crisis era warrant the investigation. Regarding the study of spatial patterns of long-term residence, classical 'micro' or 'macro' approaches are used to examine factors underlying migration intention (Cadwallader, 1989). To identify reasons for spatial patterns of long-term residence, the combination of these two approaches deserves more attention.

By using CMDS data for 2012–2014, CLDS data for 2014–2016, and macroscale urban data, we defined the length of long-term residence among members of the urban floating population in China, determined the spatial pattern of long-term residence, and explored the mechanism explaining the spatial pattern. The implications of this study lie in the following three aspects: first, on the basis of the objective survival analysis method, this study provided a criterion for defining the long-term residence of the urban floating population in China. Second, this study focused on behavior rather than intentions to analyze the spatial pattern of long-term residence and its influencing factors in the urban floating population. Third, we developed an urban spatial utility equilibrium model containing macro urban factors and micro individual and household factors to explain the spatial pattern of long-term residential behavior. The conclusions of this paper can be used to provide a reference for policymakers and planners when formulating urban development strategies.

2 Literature Review

2.1 Research on the long-term residence of China's urban floating population

When examining the settlement of China's urban floating population, researchers have often paid more attention to macroscale spatial pattern among different cities rather than the floating population of a single city. In terms of data selection, microscale survey data have generally been employed to determine and explain the distribution pattern (Lao and Shen, 2015; Cao et al., 2018). Recently, the CMDS conducted by the China Health Planning Commission has become a reliable data source, having a large sample size and containing abundant factor information (Yang and Wei, 2017). In terms of research perspective, compared with analyzing the follow-up flow process (Lin and Zhu, 2015), researchers have preferred to analyze the floating population's willingness to settle permanently because of the deficiency of tracking elements in traditional survey data (Cai and Wang, 2007; Wei, 2013). Regarding both urban development and the development of the floating population itself, the follow-up flow process of the floating population deserves more attention (Cai, 2001).

When discussing the long-term residence of the urban floating population, the first question is which year should be identified as that in which the long-term residence of a migrant began. The research has not yet provided a reliable criterion for defining the long-term residence of China's floating population. Some studies suggest 'residence for 5 yr or more' as a criterion for the long-term residence. Li (2007) divided the floating population in Guangdong Province into long-term residents, short-term residents, and transitional residents, with long-term residence defined as living in a city for 5 yr or more. Yang and Wei (2017) also employed 5 yr or more to represent long-term residence according to the question in the CMDS questionnaire: 'Do you plan to live here for a long time (more than 5 yr)?' However, the '5 yr or more' criterion lacks sufficient verification and recognition. For example, using population census data from the year 2000 and sample survey data for the floating population in Shanghai in 2003, Ren (2006) discovered that long-term residence could be defined only if migrants had lived in Shanghai for 10 yr.

In addition, empirical studies have not proposed a reasonable approach to estimating the long-term residence of the urban floating population. Fortunately, 'survival analysis', an approach ordinarily used by demographers to estimate the survival of specific groups, has become a breakthrough method of estimating long-term residence. The key to survival analysis is the survival analysis curve, which lowers with the passage of time. This curve reveals the probability change when the survival time of the observed variable is longer than the research time (Gokovali et al., 2007). Some researchers have previously employed survival analysis to study the residence characteristics of China's floating population. For example, Ren (2006) obtained a curve that decreased with increasing residence time and found this curve to be stable for as long as 10 yr after migrants had moved to a city. However, one study identified 'year 7' as the inflection point at which the slope of the survival curve decreased from large to small (Lin and Zhu, 2015).

2.2 Spatial differences in the long-term residence of China's urban floating population

The spatial differences in the long-term residence of China's urban floating population have become the focus of economic geographers and urban policymakers (Wu et al., 2018). From the spatial distribution perspective, China has witnessed large-scale polarization of the urban floating population, with people migrating from the center and west of the country to the eastern coastal urban agglomerations, such as the Yangtze River delta, Pearl River delta, and Beijing-Tianjin-Hebei urban agglomerations (Shen, 2012) and especially their megacities (Yu, 2012). Shen (2012) used credible census data to discuss the temporal and spatial evolution of China's floating population from 1985 to 2000 and discovered that the eastern coastal areas of Beijing and Tianjin and the provinces of Guangdong, Zhejiang, and Fujian are the areas to which migrants most commonly move. Cao et al. (2018) compared the spatial differences in residence of China's urban floating population at the provincial scale and revealed that the phenomenon of migrants moving to eastern coastal megacities is continually and increasingly polarized.

In the 'new era', however, the external impetus and internal attraction of China's urban development have changed. First, the world environment has altered. After the financial crisis in 2008, the purchasing power of Western countries for Chinese commodities has declined. Thus, some cities where manufacture goods were mainly for export have been unable to provide numerous jobs to the floating population. Second, China's labor market environment has changed. The Lewis turning point has been reached, resulting in the disappearance of the demographic dividend in eastern coastal cities (Cai, 2010). Furthermore, with incomes generally increasing in central and western cities, there has been an outflow of the floating population in some coastal cities. Third, the social welfare of the floating population has gradually been improved. Because of the new labor law, passed in 2008, and a new generation of migrant workers, the floating population has increasingly enjoyed the same welfare rights as the registered population (Liang et al., 2014). In fact, Li (2012) demonstrated that since 2010, cities in China have entered the urbanization stage of 'high costs and benefit'.

Because of the aforementioned changes, the spatial pattern of the long-term residence of China's urban floating population has changed. First, large-scale 'labor reflow' is occurring in central and western cities (Tang and Hao, 2019). Liu et al. (2015) used China's national census data to discover that the size of the floating population who moved within a province was close to the size of the interprovincial floating population in 2010; the authors also proposed that the dominant mode of population urbanization in the future would be 'permanent inter-county migration within a province'. Moreover, besides prosperous large cities, counties near migrants' hometowns are beginning long-term residence areas for the floating population in China (Zhu and Chen, 2010). Second, migrants prefered to move to the coastal metropolises. Using detailed population survey data for 2006, Zhu and Chen (2010) proved that the spatial residence pattern of China's floating population has become less heterogeneous; migrants prefer to move to an eastern megacity, their original county of residence, or the county near their hometown. By comparing migration trends in the floating population in 2000 and 2010, Cao et al. (2018) discovered that the floating populating preferred to move to larger coastal megacities in 2010 compared with 2000. The developed eastern cities and some crucial economic central cities will continue to be the focus of growth for China's floating population (Cao et al., 2018).

2.3 Explanatory mechanism of long-term residence of China's urban floating population

Micro and macro approaches (Cadwallader, 1989) are separate classical approaches to examining factors underlying the residential behavior of China's urban floating population (Gu et al., 2019). The micro approach attempts to explain migration under the context of the psychological decision-making process, and micro factors include individual and familial factors. Individual factors that affect long-term residence include demographic characteristics (sex, age, and education level) (Liu and Xu, 2017), income-related elements (Tong and Wang, 2015), and migration distance (Cao et al., 2018). For instance, Yang and Wei (2017) employed dynamic monitoring data on China's floating population in 2015 to demonstrate that education and income level significantly affect the long-term residential intentions of migrants. Additionally, by using sample survey data on 1% of China's population, Liu and Xu (2017) analyzed factors affecting residence selection probability in the urban floating population. They demonstrated that female, the young, the unmarried, and the highly educated were more likely to migrate to large cities. Regarding familial factors, the number of family members moving with a migrant significantly affects long-term residence (Graves and Linneman, 1979; Stark and Levhari, 1982; Chen and Rosenthal, 2008). For example, Sheng (2017) indicated that household income and the number of concomitantly moving family members were the two main factors influencing the migration decision in China.

Macro urban factors are critical in explaining migration intentions of the floating population, particularly to explaining spatial differences of intentions (He et al., 2016; Lin and Zhu, 2016). Those factors that significantly affect long-term residence include the urban socioeconomic environment, such as gross domestic product (GDP), population size, and internationalization elements (Shen, 2012; Gu et al., 2019), and urban physical environments, such as temperature severity index and green land areas (Liu and Shen, 2014). Shen (2012) developed a model that included macroscopic urban factors and reflected the migration intentions of the floating population on the basis of existing microscale factors. The study revealed that income, population size, and investment environment significantly affected settlement intentions among the floating population. Yu (2012) constructed a systematic model of the urban factors influencing long-term residence and demonstrated that a city's modernity and internationalization elements were crucial to attracting members of the floating population in China. In addition, Liu and Shen (2014) examined regional and personal factors that shape the destination decisions of skilled members of the urban floating population and demonstrated that in addition to personal factors, natural and human-made amenities significantly affected their settlement intentions. Moreover, compared with approaches that employ either microscale or macroscale elements, methods that combine the two scales can more effectively explain the migration intentions of the floating population in cities, and these methods are the most appropriate for studying spatial differences in long-term residence of this population (Cadwallader, 1989; Fan, 2005). Researchers have even begun to use the classical individual utility maximization framework of estimating people's flow intentions between regions (Glaeser and Gottlieb, 2009) to define microscale and macroscale elements (Duranton and Puga, 2004; Liu and Xu, 2017).

In summary, the combination of microscale survey data with macroscale urban data is necessary to accurately identify and explain spatial differences in the long-term residence patterns of China's urban floating population. However, a reliable criterion or approach for defining long-term residence has not yet been determined. Therefore, we first defined the duration of long-term residence among migrants by employing survival analysis. To investigate the spatial pattern of long-term residence of the floating population, we considered changes in the external impetus and internal attraction of urban development and focused on the labor reflow phenomenon and the tendency to move to large coastal cities. Moreover, we developed a model based on the individual utility maximization framework that combined macroscale and microscale elements to upgrade the explanation of spatial differences in long-term residence.

3 Research Methods and Data Sources

3.1 Criterion for defining the long-term residence of China's urban floating population

Survival analysis is a statistical method for studying individual survival probability and its response time. It is generally expressed as follows:

$$P(t_i) = P(T = t_i)(i = 1, 2, ..., k) \quad (1)$$

where $P(t_i)$ is a survival function of the probability that migrant i resides longer than exit time t; T is the length of residence after migrant i has moved to a city. When T is a discrete random datum, the survival function of the exit time t for migrant i is expressed as:

$$S(t_i) = P(T > t) = \sum_{t_i} P(t_i) \quad (2)$$

where S is the survival and $P()$ is a probability function. Equation (2) is the final probability function, and the curve corresponding to the Equation (2) is a survival curve with a decreasing slope. We use two sets of microscale survey data—CMDS and CLDS data—to obtain the survival curve of China's urban floating population. The CMDS data reflect the time points at which migrants moved to different cities but do not indicate when these migrants moved out of the cities; thus, we also use the CLDS data, which indicate when the migrants moved out of the cities. In the survival function, the exit time t, obtained from the CLDS data, is the time point of the last migration of a migrant.

To define the long-term residence of the urban floating population, we identify the inflection point of the survival curve at which the slope changes from large to small. In general, most of China's urban floating population move out of a city within 1–3 yr; therefore, the survival probability of the urban floating population should decrease sharply within 1–3 yr. However, as time goes on, the deceleration rate of the survival probability slows down; the inflection point of the survival curve is thus crucial to maintaining a stable survival probability (Lin and Zhu, 2016). This inflection point is employed as the critical year to define the duration of the long-term residence among the urban floating population in China.

3.2 Model of factors affecting long-term residence

The classic approach to analyzing factors underlying migration destination choices is based on the random utility maximization framework (Cadwallader, 1989; Davies et al., 2001). In Cadwallader's (1989) framework, micro and macro factors for migration destination choices are studied simultaneously. Micro factors include individual income, individual characteristics, and familial migration factors, where individual income and individual factors are the basis for a migrants decision to move (Tong and Wang, 2015), and the number of family members moving with a migrant also affects migration destination (Stark and Levhari, 1982; Chen and Rosenthal, 2008). Macro factors include the destination's economy and amenities because the decision to move is generally based on a rational consideration of the migration destination (Liu and Shen, 2014; Liu and Xu, 2017).

Thus, the utility of a migrant in a city U_{ij} consists of individual labor-force utility U_i, family labor-force utility U_h, and urban utility U_j. the utility model could be interpreted as follows:

$$U_{ij}=F(U_i, U_h, U_j) \quad (3)$$

where U_{ij} is the utility function U of migrant i of household h in city j; U_i includes individual income and individual characteristics (e.g., age, sex, and education); U_h contains the number of family members moving with the migrant, household income level and expenditure level; and U_j comprises urban socioeconomic and physical environments (Cadwallader, 1989).

The aforementioned utility maximization framework could not be used to interpret long-term resident behavior, but it provided a valuable reference for the selection of basic factors in this study. The long-term residential behavior of a migrant involves a spatial equilibrium between cities, and the utility of individuals should be equal across cities in the long-term residence condition (Glaeser and Gottlieb, 2009). Therefore, the spatial equilibrium framework should also be considered in the analysis of factors underlying long-term residential behavior. On the basis of the fundamental work by Rosen-and Roback, Glaeser (2011) proposed an urban simultaneous spatial equilibrium model. These spatial equilibrium models reflect the respective relationships of three explanatory variables (productivity, consumer amenities, and land areas) with three response variables (population density, wages, and housing prices), which are expressed as Equations (4)–(6).

$$\ln(PD) = \alpha_1 + \beta_1 \ln(LS) + \gamma_1 \ln(UA) + \delta_1 \ln(LA) \quad (4)$$

$$\ln(LW) = \alpha_2 + \beta_2 \ln(LS) + \gamma_2 \ln(UA) + \delta_2 \ln(LA) \quad (5)$$

$$\ln(HP) = \alpha_3 + \beta_3 \ln(LS) + \gamma_3 \ln(UA) + \delta_3 \ln(LA) \quad (6)$$

where PD, LS, UA, LA, LW, HP refer to population density, labor skills, urban amenities, land areas, labor wage, housing price, respectively. Generally, the response variable LW in Equation (5) equals to the *individual income factor* in Equation (3). Therefore, the *individual income factor* in U_{ij} can be determined by urban factors including population density, housing prices, and skills. Population density (Glaeser and Shapiro, 2003; Glaeser and Gottlieb, 2009; Chen et al., 2018), consumption environment (Glaeser et al., 2001) and housing prices (Glaeser et al., 2006) are significant determinants for urban population and economic growth. Therefore, the final spatial utility function of migrant i in city j can be expressed as shown in Equation (7).

$$U_{ij} = F(PD, LW, HP, LS, UA, IC, HE) \quad (7)$$

where IC, HE refer to individual character and household elements respectively. Equation (7) is the basic model of this study; it is a combination of the random utility maximization and spatial equilibrium frameworks. This model can not only fully consider the core factors of the utility maximization framework but also be used to interpret the long-term residential behavior of the urban floating population. Furthermore, the model derived by the simultaneous calculation of Equations (4)–(6) greatly reduced problems of endogeneity produced by the interaction between macro and micro explanatory factors.

We further assume that the spatial utility U_{ij} in Equation (7) is composed of a series of determinable factors and a random disturbance term, which is expressed as Equation (8).

$$U_{ij} = \theta x_{ij} + \varepsilon_{ij} \quad (8)$$

where $x_{ij}, \theta, \varepsilon_{ij}$ is a series of determinable factor combinations, the coefficient vector, the random disturbance term, respectively. Because i and j are discrete variables, the probability that migrant i chooses long-termresidence is the probability that the spatial utility function U_{ij} is greater than 0. If the random disturbance term ε_{ij} obeys the normal distribution, then the probit regression model of long-term residence of migrant i in city j can be expressed as Equation (9).

$$P(\text{choice} = 1) = P\left[U_{ij} > 0\right] = P\left[\varepsilon_{ij} < \theta x_{ij}\right] = F(\theta x_{ij}) \quad (9)$$

where $F()$ is the cumulative distribution function of the standard normal distribution, and $P(\text{choice} = 1)$ refers to the probability that migrant i is long-term resident in city j.

Apart from the description of the basic model, the selection of macroscale indicators should be discussed. First, per capita GDP, the teacher-student ratio in colleges, and the average number of theaters are critical indicators for measuring urban economies, skills, and amenities. Second, population density and housing price indexes are essential in urban agglomeration economies (Glaeser et al., 2001; Duranton and Puga, 2014), which were not widely recognized until 2000.

Population density is typically useful for measuring the positive effect of urban agglomeration and the degree of urban crowding (Ciccone, 1996). In terms of the vulnerable urban floating population, the population density or population size index increases before it decreases (inverted U shape; Henderson, 1986). The vulnerable urban floating population in China is more sensitive to urban crowding than to the positive effect of agglomeration (Chan and Zhang, 1999). What's more, during urban population agglomeration, crucial positive effects are mostly caused by the 'learning effect' (Duranton and Puga, 2014), which is only strong in megacities (Xi et al., 2019; Yu et al., 2019). The housing price index generally reflects the cost of living in cities, and this index can significantly reduce the residential behavior of the urban floating population (Liu et al., 2017). The housing price index also reflects megacity consumption environments, which can increase urban population growth (Glaeser et al., 2001; Glaeser and Gottlieb, 2006). The adverse effect of housing prices on the agglomeration of the vulnerable floating population is weaker in more prosperous cities because migrant residents prefer to rent rather than buy houses or apartments (Qin et al., 2018).

For these reasons, this study proposes the following two preliminary assumptions. First, population density negatively affects the long-term residence of the floating population moving to small cities while positively affects that of the floating population moving to megacities. Second, housing price negatively affects the long-term residence of the floating population moving to small cities with lower housing prices. If housing prices reach the level where the migrants can not afford the house, the migrants will be more likely to rent houses than buying them. Therefore, we assume that the effects of population density and housing price on the long-term residence of urban floating population are negative first and then positive.

3.3 Data sources

The sources of microscale data in this paper are the China Migrants Dynamic Survey (CMDS) from 2012 to 2014, and China Labor-force Dynamics Survey (CLDS) in 2014 and 2016. CMDS is a large-scale national survey conducted by the National Health Commission once a year and focuses on the floating population aged 16–59 who has granted permission. The methods of this survey are stratified, multi-stage and sampling with probability proportional to size, and its annual sample size are near 200 000. CLDS conducted by Center for Social Survey of Sun Yat-sen University is a biennial tracking survey on the labor force aged 15–64, and has completed a collection of 3 yr (2012, 2014 and 2016). This dataset is an open-source data to all the teachers and students of Sun Yat-sen University, and we acquired this dataset in 2017 as PHD candidates. Macroscale data excluding Hongkong, Macao and Taiwan of China are obtained from the China Urban Statistical Yearbook and China Regional Economic Statistical Yearbook and Defense Meteorological Satellite Program–Operational Linescan System (DMSP/OLS) Nighttime Lights data (Yao et al., 2018; Chen et al., 2018).

The advantages of the microscale data employed lie in its two sources and long-time span. The CMDS is a large sample data set with more than 200 000 respondents from 262 prefecture-level cities, enabling the spatial pattern of the long-term residence of China's urban floating population to be studied comprehensively. However, the CMDS data do not reveal when migrants moved out of their city. To clarify the long-term residence situation of the urban floating population, we further use the supplementary data of the CLDS. The advantage of CLDS data is that it includes the historical migration trajectory of migrants, making it possible to apply survival analysis. However, CLDS contains the defects of small sample size and limited coverage of cities, which could fully reflect the spatial pattern of long-term residence of the urban floating population in China. Overall, the application of both data sets ensures the accuracy and rationality of the research results.

Moreover, we match the microscale data of migrants with the macroeconomic data of cities to emphasize the effects of urban factors on the residence of the floating population. Because of considerable difficulty in data collection, we employ macroscale data for only 2010 and 2013; the macroeconomic data for 2010 are used to represent the situation in 2012, whereas the data of 2013 represent the situation of 2013, 2014, and 2016. As mentioned previously, the factors employed herein to represent prefecture-level cities, including population density index, per capita GDP, urban housing price index, number of opera houses, and teacher-student ratio in universities. Population density is the permanent urban population size divided by the area of built-upon land, and the size of the permanent urban population is the sum of the registered population and temporary population. Registered population data are obtained from the *China City Statistical Yearbook* (2011; 2014) (NBSC, 2011; 2014) while temporary population data from the *China Urban Construction Statistical Yearbook* (2010; 2013) (MOHURD, 2010; 2013). Urban construction land data are obtained from the DMSP/OLS Nighttime Lights by using the spatiotemporal normalized threshold method. This dataset is obtained by dividing the national night light data into more than 2800 NTL images at county scale based on the TM 30 meters data in 2010, which can greatly improve the accuracy of the urban construction land area data (Chen et al., 2018; Yao et al., 2018). Urban housing price data are extracted from *China Statistical Yearbook for Regional Economy* (2011; 2014) (NBSC, 2011; 2014). Other data including the number of opera houses, teacher-student ratio in universities are extracted from the *China City Statistical Yearbook* (2011; 2014) (NBSC, 2011; 2014). In order to clarify the spatial pattern of long-term residence, we choose the criterion of the four economic regions processed by National Bureau of Statistics (NBSC, 2013). The four economic regions are eastern China, central China, western China and northeastern China. Eastern China consists of Beijing, Tianjin, Hebei, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong and Hainan. Central China consists of Shanxi, Anhui, Jiangxi, Henan, Hubei, Hunan. Western China consists of Inner Mongolia, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Shannxi, Gansu, Qinghai, Ningxia and Xinjiang. Northeastern China consists of Liaoning, Jilin and Heilongjiang. The study doesn't include Taiwan, Hong Kong and Macao.

We process the original microscale survey data as follows. For CMDS data, we consider 262 prefecture-level cities where statistics are available for the period 2012–2014; thus, contrastive study of different years could be performed. Cities not included in CMDS 2012 are Chaoyang, Mudanjiang, Laiwu, Maoming, Guang'an, Ya'an, Yichun, Zaozhuang, Taian, Ezhou, Suizhou, Shanwei, and Jieyang. Cities excluded from CMDS 2013 are Quzhou, Heze, Hebi, Xuchang, Shangqiu, Zhoukou, Jiyuan, Meizhou, and Yangjiang. Cities not studied in CMDS 2014 are Fuxin, Qitaihe, Quzhou, Hebi, Xuchang, Shangqiu, Zhoukou, Jiyuan, Meizhou, Yangjiang, and Yunfu. For CLDS data, we select the survey years 2014 and 2016 and employ historical data of the last migration of migrants from 2008 to 2016. After this data cleaning, the CMDS dataset in 2012, 2013, and 2014 have contained data on 142 021, 179 512, and 179 963 individuals, respectively, whereas the CLDS dataset in 2014 and 2016 contain data on 2217 and 1,369 people respectively. The summary of the statistics of key variables is presented in Table 1.

4 Results

4.1 Determination of the inflection point of long-term residence

Using the two robust sets of microscale survey data, we obtain the survival probability curve of the floating population (Figs. 1 and 2). The inflection points of the curves, at which the slopes of the survival curve change from large to small, are identified and used as the criteria for defining long-term residence of China's urban floating population. We discover that '5 yr' corresponds to the inflection point at which China's urban floating population changes status from short-term to long-term residence; that is, those living in a city for six or more years are identified as long-term residents.

Fig. 1 presents the survival curve of the long-term residence of China's urban floating population obtained

Table 1 Statistics of the key variables

CMDS	2012			2013			2014		
	N	Mean	SD	*N*	Mean	SD	*N*	Mean	SD
Length of residence	136870	4.321	(4.520)	171964	4.500	(4.554)	172084	4.409	(4.547)
Gender	136870	0.525	(0.499)	171964	0.534	(0.499)	172084	0.579	(0.494)
Age	136870	33.402	(9.208)	171964	33.631	(9.178)	172084	33.846	(9.245)
Edu	136870	9.803	(2.764)	171964	9.863	(2.716)	172084	10.110	(2.864)
Ln (population density)	133072	8.689	(0.592)	165684	8.573	(0.580)	166687	8.580	(0.575)
Ln (housing price)	136870	8.736	(0.635)	171964	8.842	(0.513)	172084	8.842	(0.511)
Ln (urban income)	136870	10.660	(0.596)	165684	10.813	(0.679)	166687	10.832	(0.662)
Number of theatre	136471	31.603	(44.14)	171844	32.613	(57.15)	171924	32.952	(57.080)
Teacher student ratio	135594	0.063	(0.014)	171964	0.060	(0.017)	172084	0.060	(0.017)

CLDS	2014			2016		
	N	Mean	SD	*N*	Mean	SD
Length of residence	2117	6.107	(4.160)	1369	6.604	(4.700)
Gender	2117	0.443	(0.497)	1369	0.457	(0.498)
Age	2102	34.624	(11.240)	1363	35.158	(11.248)
Edu	2116	10.635	(3.801)	1368	10.613	(3.883)
Ln (population density)	2117	8.795	(0.517)	1369	8.830	(0.491)
Ln (housing price)	2117	8.748	(0.652)	1369	8.787	(0.634)
Ln (urban income)	2117	10.726	(0.656)	1369	10.794	(0.623)
Number of theatre	2112	26.212	(31.801)	1362	28.853	(36.992)
Teacher student ratio	2117	0.142	(0.074)	1369	0.145	(0.078)

Notes: The education variable is expressed by the actual years of education of the labor force. For the mean of age, the China Migrants Dynamic Survey (CMDS) data corresponds to the mean age of the floating population aged 16–59, and the China Labor-force Dynamics Survey (CLDS) data corresponds to the mean age of the labor force aged 15–64. The unit of population density is persons/km^2; housing price is yuan (RMB)/km^2; and urban income, expressed in per capita GDP, yuan(RMB)/person.

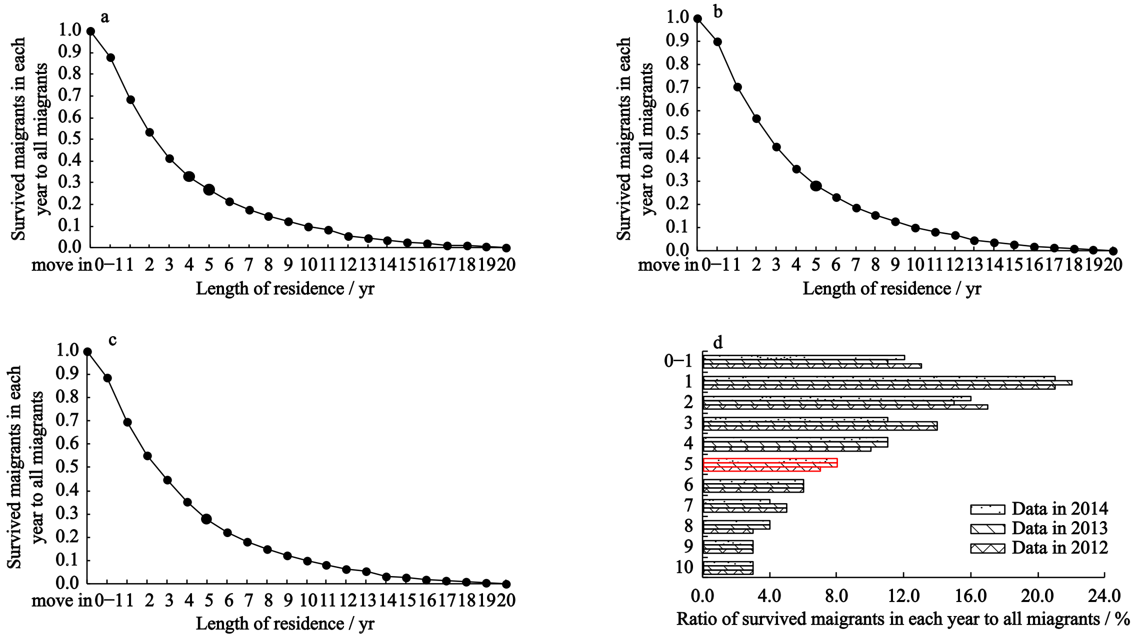

Fig. 1 Determining the inflection point of the survival curves obtained using China Migrants Dynamic Survey (CMDS) data on the long-term residence of the floating population. Figs. 1a, 1b, and 1c are the survival curves obtained using 2012, 2013, and 2014 data, respectively. Fig. 1d shows the proportion of the floating population that stayed in their city for the indicated periods

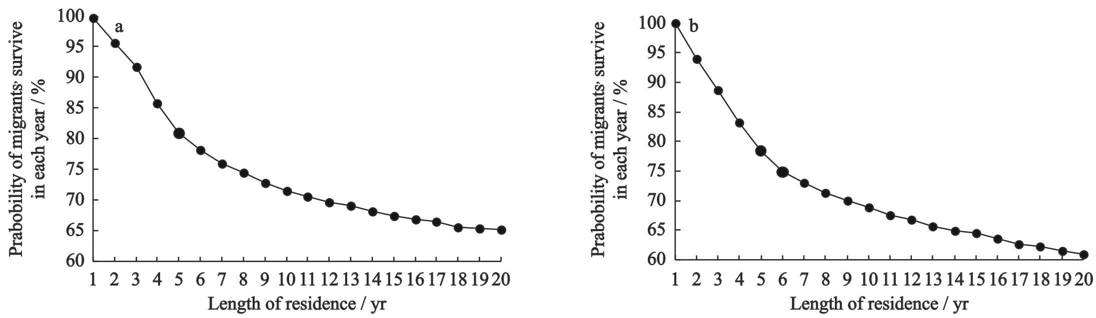

Fig. 2 Survival curve of China's floating population based on China Labor-force Dynamics Survey (CLDS) data. Figs. 2a and 2b are the survival curves of urban residence of the floating population in 2014 and 2016, respectively. This graph is obtained using the Kaplan–Meier method of survival analysis

through the CMDS dataset from 2012 to 2014. The curves suggest that 5 yr is the inflection point. Specifically, Fig. 1a shows the survival curves based on the 2012 CMDS data. This figure meets the criterion for the basic form of a survival curve, being a smooth convex curve enclosing the origin with the slope decreasing. Crucially, the inflection point is found to be located at both 4 and 5 yr, and the survival probability of a migrant staying in a city for less than or equal to 4 yr is greater than 40%, whereas the survival probability of a migrant staying in a city for more than or equal to 6 yr is less than 25%. Similarly, Figs. 1b and 1c present the survival curves based on CMDS data for 2013 and 2014, respectively. The inflection point in these figures is solely at 5 yr. To verify the accuracy of the results of Figs. 1a–1c, we plotted Fig. 1d, which illustrates the proportion of the total floating population that stayed in their city for 0–1 yr, 1 yr, 2 yr, …, up to 10 yr. Fig. 1d confirms that 5 yr corresponds to the inflection point at which the proportion of the total floating population becomes similar from year to year. In the first five years of residence of the floating population, the average decline rate of the survival proportion is 22.2%, whereas during the 6–10 yr after the inflow, the average decline rate is only 15.9%.

Fig. 2 displays the survival curve obtained using the CLDS data for 2014 and 2016. The research results again indicate that 5 yr is the inflection point. Specifically, Fig. 2a is the survival curve obtained using CLDS data for 2014, and we found that the slope of the survival curve changes from large to small at 5 yr. The average decline rate of the survival probability from 1 yr to 5 yr is 5.4%, whereas the average decline rate from 6 to 10 yr is only 2.9%. Similar to Figs. 2a, 2b shows the survival curve obtained using CLDS data for 2016 and indicates that the inflection point is between 5 and 6 yr.

Compared with those in Fig. 1, the survival probabilities plotted in Fig. 2 are considerably higher. This is probably because the CLDS data used to plot Fig. 2 reflect the outflow condition of the urban floating population; that is, the curve estimates the actual outflow of migrant i after t yr of residence in city j. Thus, compared with the curve in Fig. 1, which neglects the outflow of the urban floating population, the survival probability in Fig. 2 is more accurate. Otherwise, the CMDS data employed to obtain Fig. 1 include data for 0–1 yr. By contrast, the CLDS data employed to obtain Fig. 2 reflect the survival probability from the first year after beginning residence; thus, the exit probability of residence of 0–1 yr is coded as being that for 0 yr.

4.2 Spatial pattern of long-term residence

We wish to determine the spatial pattern of the long-term residence of China's urban floating population. Using the index of the proportion of the floating population that has resided in a city for 6 yr or more, we analyze this proportion in each prefecture-level city and then obtain the spatial pattern of long-term residence of China's urban floating population. The results show that the regions in which migrants are more likely to be long-term residents are the megacities in the three urban agglomerations in eastern China (Yangtze River Delta, Pearl River Delta, and Beijing-Tianjin-Hebei Urban Agglomerations) as well as small and medium-sized cities in western China and northeastern China; by contrast, the short-term residence areas are more commonly the cities in central China and near the three urban agglomerations in eastern China.

Fig. 3 displays the spatial distribution of long-term residence that was obtained using CMDS data for 2012–2014. Three crucial findings are obtained through the analysis of the special patterns of 2012, 2013 and 2014. First, the three urban agglomerations in eastern China are common long-term residence regions of the urban floating population in China. Second, cities in central China and near the three large metropolitan areas are the regions in which migrants have the shortest residence. Third, cities in western China and northeastern China, especially small and medium-sized cities, are also important long-term residence regions of China's urban floating population.

Fig. 3a depicts the spatial distribution obtained using CMDS data for 2012. The proportion of the floating population residing in the three urban agglomerations urban agglomerations and cities in western China and northeastern China who are long-term residents of these cities is higher than 28% (i.e., less than 72% of these residents are short-term residents), whereas for cities in central China and near the large three urban agglomerations in eastern China, this proportion is less than 24%. Specifically, the average proportion of the total floating population who are long-term residents in one of the three urban agglomerations is 27.9%, and those for the migrants who are long-term residents in the first-tier cities—Beijing, Shanghai, Guangzhou, and Shenzhen—are higher at 39%, 45%, 32%, and 30% respectively. Regarding the western cities, the average proportion is 28.8%, and the traditionally labor exporting cities and immigrant cities have high rates of long-term residence. For example, Dazhou, traditionally a labor exporting city, has 36% of the floating population who are long-term residents, whereas the corresponding percentage for Panzhihua, a traditional immigrant city, is 37%. In addition, the proportion of cities in northeastern China is even higher at 37.3%, with those of Shuangyashan and Heihe being 52% and 60%, respectively. However, the long-term-resident proportion of the urban floating population in cities near the large three urban agglomerationsurban agglomerations in eastern China and in the cities in central China is only 23.6% and 22.8%, respectively. The short-term residence characteristics of the urban floating population are particularly prominent for some provincial capitals and large-scale cities, such as Jinan, Hefei, and Fuyang, for which the proportions are only 14%, 13%, and 6%, respectively.

Figs. 3b and 3c depict the spatial distribution pattern obtained using the 2013 and 2014 data. They also show that the three urban agglomerations and the cities in western China and northeastern China are notable long-term residence areas, with proportions of long-term residence of 29%, 36%, and 31% respectively. By contrast,

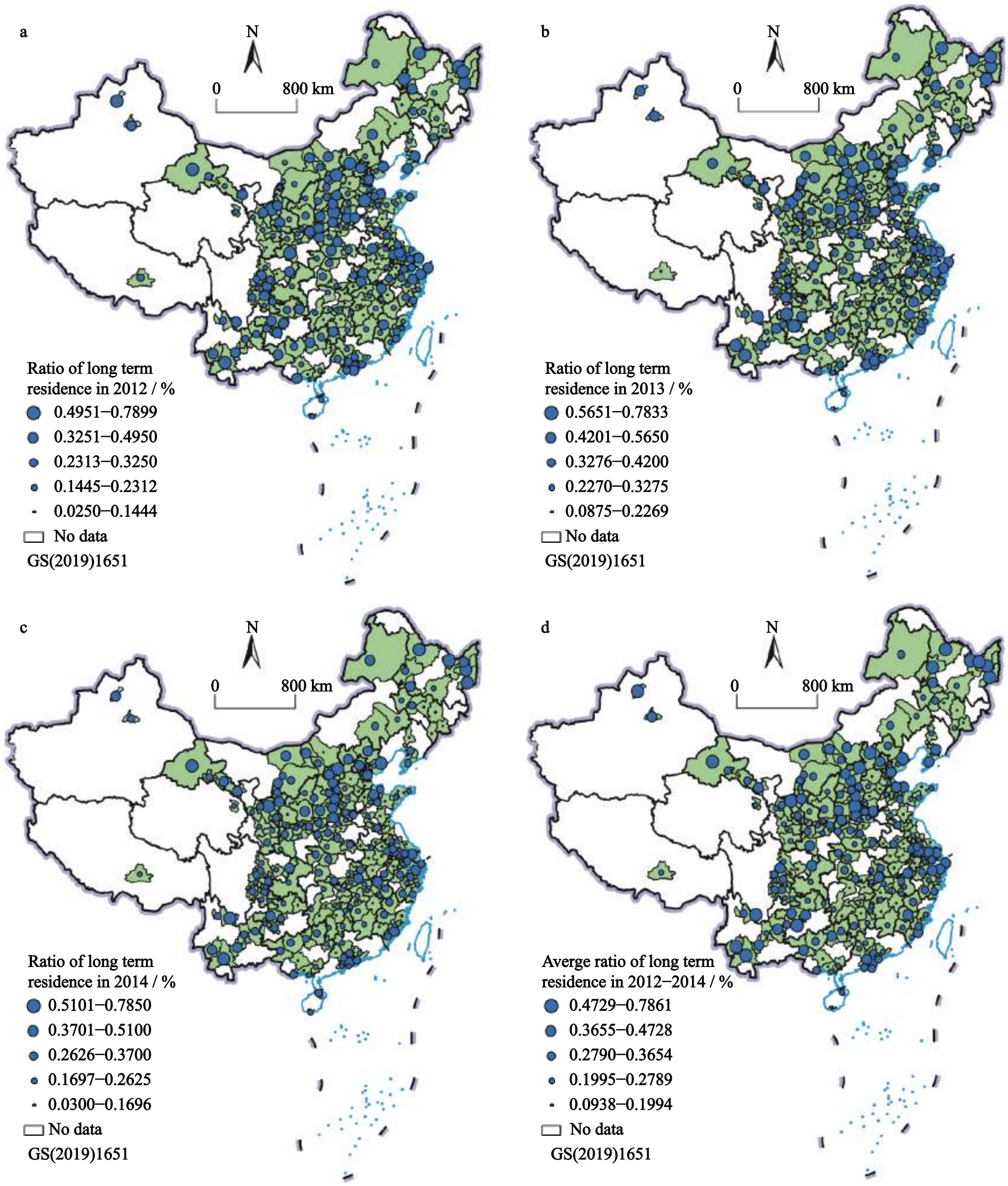

Fig. 3 Spatial pattern of long-term residence of China's urban floating population, obtained from China Migrants Dynamic Survey (CMDS) data without Hong Kong, Macao and Taiwan of China. Figs. 3a, 3b, and 3c show the spatial pattern in 2012, 2013, and 2014, respectively. The spatial pattern displayed in Fig. 3d is based on the proportion of the floating population residing for 6 yr or more during 2012–1014

cities in central China and other cities in eastern China are common short-term residence areas, with proportions of 24% and 25%, respectively. We also depict the proportion of long-term residents among the floating population for each city from 2012 to 2014 (Fig. 3d) and find that this spatial distribution pattern is consistent with those in Figs. 3a–3c.

Using the CMDS data for 2012–2014 and CLDS data for 2014 and 2016, we further calculate the average time of residence of the floating population by region and city size (Table 2). The results prove the accuracy of the findings obtained from Fig. 3. Regarding the CMDS data, the average residence time is longer than 4.6 yr in the three urban agglomerations and cities in northeastern China, 4.5 yr in cities in western China, and only 4 yr in cities in central China and other cities in eastern

China. Simultaneously, the average residence time is longer than 4.8 yr in megacities, 4.5 yr in small and medium-sized cities, and less than 4 yr in big cities. We obtain the same results using the CLDS data. Notably, however, the probable reason for the difference of average resident time shown by CLDS and CMDS is that the CLDS data contain the outflow information of the urban floating population, which is usually larger than the data that do not contain the outflow information.

4.3 Explanation of the spatial pattern of long-term residence

Table 3 reports the regression results obtained using Equation (9) and the CMDS data. Urban density and urban housing price are discovered to both exert a 'U-shaped' influence on long-term residence of the urban floating population, whereas urban income, number of theaters per capita, and teacher-student ratio have significantly positive effects in all models. Columns 1 and 2 in Table 3 present the regression results for the 2012 CMDS data. As expected, the coefficients for population density and housing price are significantly negative and their quadratic coefficients are positive, indicating that the influences of population density and housing price on long-term residence are U-shaped. Additionally, urban income, number of theaters, and teacher-student ratio have significant positive impacts. Specifically, in column 1, the coefficient of urban population density and its square term are –0.386 and 0.01, respectively.

When controlling the microscale individual and familial elements (column 2), the effects of the two variables are largely the same in terms of significance level and sign, with the coefficient of urban population density and its square being −0.211 and 0.006, respectively, and the coefficient of urban housing price and its square term being −0.787 and 0.047, respectively. Columns 3 and 4 and columns 5 and 6 present the results for 2013 and 2014, respectively. The sign and significance of the core variables are relatively consistent, supporting the conclusion that the effects of urban density and housing price are U-shaped and that of urban agglomeration factors is significantly positive. Regarding the control variables, compared with individual elements, familial elements, especially household income and number of family members moving together, make a more significant contribution to the long-term residence of the floating population.

For the CLDS data, Table 4 reports the results obtained using Cox and Weibull regression, which support the findings presented in Table 3. Columns 1 and 2 show the results of the Cox model, with column 1 showing the results for model including only macroscale urban elements. For this model, urban density and urban housing price are found to exert U-shaped effects on long-term residence, with coefficients and quadratic coefficients of −0.783, −0.161 and 0.050, 0.022 respectively. The coefficients for urban income and number of theaters per capita are again positive and highly significant, whereas the coefficient for teacher-student ratio is significantly negative, which indicates that the positive influence of the college and university element is not ro-

Table 2 Spatial differences in average residence time of urban floating population in China

Classification	Different types of cities	CMDS				CLDS	
		2012	2013	2014	average	2014	2016
By region	Three Urban Agglomerations in Eastern China	4.86	4.86	4.71	4.81	5.62	5.94
	Cities in Eastern China without Three Urban Agglomerations	3.83	4.18	4.00	4.00	5.34	5.42
	Cities in Central China	3.69	4.15	4.22	4.02	5.42	5.27
	Cities in Northeastern China	4.67	5.03	4.94	4.88	5.96	5.97
	Cities in Western China	4.21	4.60	4.60	4.47	6.14	5.74
By city size	Megacities (> 10 million residents)	5.08	4.98	4.83	4.96	5.52	5.95
	Big cities (5–10 million residents)	3.70	4.00	3.88	3.86	5.38	5.74
	Medium cities (3–5 million residents)	4.34	4.59	4.68	4.64	5.54	5.83
	Small cities (< 3 million residents)	4.38	4.87	5.09	4.78	6.07	6.03

Notes: The average data for the China Migrants Dynamic Survey (CMDS) are based on the average residence time of the total floating population in each region from 2012 to 2014. Data sources: China Migrants Dynamic Survey (CMDS) 2012–2014; China Labor-force Dynamics Survey (CLDS) 2014 and 2016

Table 3 Explanation of long-term residence based on probit regression

Elements	Explanatory variables	2012		2013		2014	
		(1)	(2)	(3)	(4)	(5)	(6)
Urban elements	Population density	–0.386***	–0.211**	–0.501***	–0.378***	–0.499***	–0.353***
		(–2.973)	(–2.179)	(–8.066)	(–6.438)	(–8.027)	(–5.953)
	Population density square	0.010***	0.006**	0.026***	0.019***	0.025***	0.017***
		(2.676)	(2.073)	(6.942)	(5.439)	(6.657)	(4.772)
	Housing price	–0.850***	–0.787***	–1.131***	–0.854***	–1.381***	–1.178***
		(–13.433)	(–12.947)	(–13.665)	(–10.924)	(–17.072)	(–15.229)
	Housing price square	0.051***	0.047***	0.064***	0.049***	0.076***	0.065***
		(14.060)	(13.610)	(13.743)	(11.199)	(16.788)	(15.060)
	Urban income	0.017***	0.012***	0.075***	0.059***	0.097***	0.080***
		(4.625)	(3.272)	(18.478)	(15.459)	(25.181)	(21.728)
	Number of theatre per capita	0.128**	0.016***	0.128*	0.119	0.253**	0.217
		(2.572)	(3.341)	(1.932)	(1.566)	(2.247)	(1.349)
	Teacher student ratio	1.787***	1.598***	0.867***	0.848***	1.157***	1.174***
		(17.952)	(16.724)	(11.062)	(11.461)	(14.756)	(15.641)
Micro individual elements	Gender		–0.003		0.002		0.013***
			(–1.288)		(0.941)		(6.050)
	Age		0.010***		0.011***		0.010***
			(67.111)		(87.423)		(76.867)
	Marriage		–0.054***		–0.038***		–0.064***
			(–9.427)		(–7.564)		(–12.627)
	Edu		–0.004***		–0.004***		–0.004***
			(–9.775)		(–9.308)		(–10.920)
Micro familial elements	Household income		0.020***		0.007**		0.006**
			(7.261)		(2.556)		(2.097)
	Household Expenditure		0.072***		0.075***		0.073***
			(25.702)		(28.285)		(28.424)
	Only spouse migration		0.043***		0.061***		0.046***
			(7.844)		(12.950)		(9.312)
	Only children migration		0.011		0.037***		0.023**
			(1.185)		(4.274)		(2.572)
	Nuclear family migration		0.115***		0.130***		0.123***
			(22.106)		(29.444)		(26.502)
	N	129407	128255	165564	164026	166527	166310
	Adjusted R^2	0.084	0.106	0.078	0.102	0.087	0.094

Notes: *t* statistics are in parentheses; ***, **, * denote statistical significance at 1%, 5%, and 10% level, respectively. Data source: China Migrants Dynamic Survey (CMDS) 2012–2014

bust. The results obtained for the models including microscale individual elements as control variables are presented in column 2, and the sign and significance of most of the urban variables are consistent except for the coefficient of urban density, which is nonsignificant. Columns 3 and 4 show the results obtained using Weibull regression, which is generally consistent with those obtained using the Cox method. Thus, the findings in Table 4 verify that the effects of urban population density and urban housing price on long-term resid-

Table 4 Explanation of long-term residence based on survival analysis

Explanatory variables	Cox		Weibull	
	(1)	(2)	(3)	(4)
Population density	–0.783**	–0.524	–0.844***	–0.582
	(–2.553)	(–1.501)	(–2.715)	(–1.625)
Population density square	0.050***	0.035**	0.052***	0.037**
	(3.308)	(2.042)	(3.422)	(2.125)
Housing price	–0.161***	–0.298**	–0.148**	–0.276*
	(–3.630)	(–2.122)	(–2.003)	(–1.865)
Housing price square	0.022***	0.022**	0.021***	0.019**
	(3.404)	(2.099)	(3.350)	(2.086)
Urban income	0.443***	0.325*	0.463***	0.366*
	(2.795)	(1.706)	(2.891)	(1.880)
Number of theatre per capita	0.539***	0.670***	0.562***	0.720***
	(10.104)	(9.171)	(10.653)	(9.799)
Teacher-student ratio	–4.239***	–4.576***	–4.214***	–4.626***
	(–6.927)	(–5.868)	(–6.873)	(–5.933)
Control variables	No	Yes	No	Yes
N	3090	1892	3090	1892

Notes: *t* statistics are in parentheses; ***, **, * denote statistical significance at 1%, 5%, and 10% level, respectively. Data source: China Labor-force Dynamics Survey (CLDS) 2014 and 2016

ence are significantly U-shaped, whereas the impact coefficients of urban income and urban consumption environment are significantly positive.

5 Discussion

When analyzing long-term residence of the urban floating population in China, researchers have preferred to analyze residential intentions or preferences rather than residential behavior because of the lack of tracking elements in conventional survey data (Lin and Zhu, 2015). Fortunately, in this study, two robust and mutually certifiable data sets, namely CMDS and CLDS, facilitated the analysis of long-term residential behavior in the urban floating population of China. Additionally, more accurate influential coefficients were obtained when we explained residential behavior by matching robust microscale survey data with macroscale urban data.

First, we demonstrated that long-term residence for the current urban floating population in China is defined as 6 yr or longer. This finding is relatively accurate because it is close to the empirical criterion of at least 5 yr of residence in the CMDS questionnaire (Yang and Wei, 2017), and the survival analysis in this study used a classical approach typically used to estimate the survival of specific groups. Furthermore, this finding differs from the criterion of at least 10 yr of residence in Shanghai estimated by Ren (2006). These inconsistencies occurred because rather than estimating long-term residence in a single city, we analyzed all cities China, and our findings demonstrate that proportion of long-term residence is relatively higher in the Yangtze River Delta, particularly in its megacities.

Second, migrants were most likely to be long-term residents of megacities in the three urban agglomerations in eastern China as well as small and medium-sized cities in western and northeastern China. This spatial pattern is consistent with current changes in urbanization in China. Population and wealth continually flow into the eastern coastal megacities, and this phenomenon is increasingly polarized (Cao et al., 2018). However, large-scale labor reflow is occurring particularly in western cities (Tang and Hao, 2019), and some of these migrant people prefer to move to small or medium-sized cities near their hometowns (Zhu and Chen, 2010). This finding indicates two types of polarization occurring in the long-term residence of the urban floating population in China (some people move to megacities in the east, whereas others prefer to live in small or medium-sized cities in the west and northeast).

Finally, we demonstrated that urban population density and urban housing prices are the main factors affecting long-term residential behavior, and both factors have significant U-shaped effects. This finding was obtained by explaining long-term residential behavior, which differs from residence intention. First, the influence of micro household factors demonstrated here are coincident with studies that have demonstrated that household income and number of concomitantly moving family members significantly improve residence intention (Chen and Rosenthal, 2008; Sheng, 2017). This comparison demonstrated that our model is reasonable. Second, for micro individual factors, destination intention researchers have indicated that the young, the unmarried, and the highly educated are more likely to migrate to large cities (Liu and Xu, 2017; Yang and Wei, 2017). However, the influence of these individual factors in the present study was negative. This was because human capital (e.g., higher education) can increase opportunities for a person to move to a megacity and reduce the costs of moving. Third, the effects of macro urban factors in the present study were more significant than those of micro individual and household factors were. However, in previous residence intention studies, the effects of macro regional factors have been less significant than those of micro individual and household factors (Shen, 2012; Liu and Shen, 2014). This finding occurred because we conducted this study at the city scale, whereas most studies have conducted research at the provincial scale (Li et al., 2012). More prosperous cities are more attractive in current society (Glaeser, 2011). Additionally, we found that urban factors have higher explanatory power regarding the spatial pattern of long-term residence than individual and familial factors do. During urban development, population density and housing prices decrease in the following sequence of areas: three urban agglomerations > cities in eastern China without three urban agglomerations > cities in central China > cities in western China > cities in northeastern China. This sequence corresponds with city size.

6 Conclusions

By matching robust microscale survey data with macroscale urban data, we analyzed and explained the spatial pattern of long-term residential behavior in the urban floating population of China. First, we developed an approach by using survival analysis and demonstrated that for the urban floating population in China, long-term residence is defined as six or more yr of residence. Second, on the basis of two sets of robust survey data, this study proved that members of the floating population are most likely to be long-term residents of megacities in the three eastern urban agglomerations as well as small and medium-sized cities in western and northeastern China, whereas short-term residence is more likely in cities in central China and near the three urban agglomerations. Third, by developing labor-force spatial utility equilibrium models that included urban factors, we indicated that urban population density and urban housing prices are the main factors affecting the spatial pattern of long-term residence, and both have significant U-shaped effects. The two factors had higher explanatory power for the spatial pattern of long-term residence than individual and familial factors did.

Although this study illustrated the present spatial pattern of long-term residence in the population of interest, in-depth research is required to explain pattern changes over time. Additionally, we demonstrated that urban population density and housing prices are crucial to explain long-term residence in the urban floating population, but how this finding can be used to analyze or plan urban growth warrants research.

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