

Article

Spatio-Temporal Paths and Influencing Factors of Residential Mobility in Guangzhou: A Micro-Level Perspective of Newly Employed College Graduates

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Abstract: Residential mobility within cities reflects the spatio-temporal patterns of individual or household relocation behaviors and serves as an effective tool for interpreting urban socio-spatial differentiation from a micro-level perspective. Newly employed college graduates (NECGs) have become the second-largest migrating population in China. This study selects Guangzhou, a megacity, as the study area and utilizes data from the “Guangzhou New Citizens’ Residential Mobility Survey” conducted in 2023. It applies spatio-temporal systems and the spatio-temporal path method based on time geography to explore the residential mobility trajectories of NECGs in Guangzhou. In addition, the study uses a logistic regression model to explore the influencing factors. The findings indicate that NECGs frequently move across districts, showing no significant patterns of concentration or dispersion. However, residential location choices vary considerably across educational levels and household registration natures (Hukou), and as the duration of residence in Guangzhou increases, the probability of residential mobility among NECGs across all educational levels shows a declining trend. Specifically, marital status (life course attributes), housing prices and medical facilities (housing attributes), and job type (socioeconomic attributes) emerge as critical factors influencing residential mobility. By providing a foundation for urban planning policies, this study aims to support the settlement and well-being of NECGs while promoting high-quality urban development in Guangzhou.

Keywords: residential mobility; newly employed college graduates (NECGs); spatio-temporal paths; influencing factors; Guangzhou



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1. Introduction

Since the reform and opening up, China’s urbanization has developed rapidly, with the urbanization rate increasing from 36.2% in 2000 to 67.0% in 2024. The permanent resident urbanization rate has now exceeded two thirds [1]. During this process, the citizenization of rural migrant workers has also accelerated continuously [2]. In the new era, high-quality development has become the primary task for China’s comprehensive construction of a modern socialist country. As an important component of urban space, population represents the most dynamic factor in urban development. Housing, as a basic urban function, is fundamentally related to people’s livelihoods.

NECGs, as an emerging migration force in China’s urbanization process, have become the second largest migrant group, following rural migrant workers [3,4]. They make important contributions to urban economic development [5]. As a special group

transitioning from campus to the workplace, NECGs are at the initial stage of their careers with relatively low income levels. In terms of housing affordability, they face extremely severe challenges [6]. The high rental and purchasing costs in cities often limit their housing choices to areas with cramped spaces, remote locations, and poor living conditions. Moreover, due to the unique career development stage they are in and the intense competition within industries, NECGs maintain a high sensitivity to career advancement opportunities and industry development trends [7]. When more attractive career prospects emerge, their exploratory and uncertain early-career phase makes them highly likely to make rapid residential mobility decisions [8]. This career-oriented, high-frequency mobility pattern demonstrates distinctive characteristics among migrant populations. Residential mobility serves as an effective approach to reveal the mechanisms of urban socio-spatial differentiation and restructuring. With the residential preferences of social groups and urban housing supply become increasingly heterogeneous, scholars in the fields of geography and housing studies have conducted a large number of empirical studies on the spatio-temporal characteristics, migration motivations, and influencing factors of residential mobility, establishing a relatively systematic theoretical and research framework [9,10]. In the study of residential mobility, time geography demonstrates unique advantages [11]. Traditional fundamental theories of residential mobility, such as push–pull theory and cost–benefit theory, mainly explore the factors influencing migration from a macro perspective. The push–pull theory emphasizes external factors, such as employment opportunities, living costs, and social welfare, in driving and attracting population migration [12]. The cost–benefit theory focuses on analyzing the costs and benefits associated with migration from an economic perspective to explain migration decisions [13]. Time geography theory, however, delves into the micro-level perspective of individuals, focusing on their activity paths in time and space. By integrating temporal and spatial elements in the migration process, this approach can visually present individuals' movement trajectories within urban geographic space at different stages, precisely identifying the characteristics and relationships of migration origin points, transitional areas, and destinations [14].

Existing studies predominantly adopt a macro perspective, focusing on general populations or specific socioeconomic classes [15,16]. These approaches pay insufficient attention to NECGs—a group characterized by high educational attainment, early career stages, and high mobility—making it difficult to accurately understand this high-potential group's residential needs and behavioral patterns [17]. Against this backdrop, this study aims to enrich empirical research on residential mobility across different groups by focusing on NECGs in Guangzhou. We conduct an in-depth exploration of their spatio-temporal mobility paths to reveal this group's urban migration patterns and influencing factors.

Our study focuses on the residential mobility of NECGs and aims to address two key questions: First, what are the spatial and temporal characteristics of NECGs' residential mobility behaviors? Second, what factors influence NECGs' residential mobility decisions?

2. Literature Review

This paper systematically reviews the literature on residential mobility, focusing on research perspectives, spatio-temporal characteristics, influencing factors, and research data and methodologies.

2.1. Research Perspectives on Residential Mobility

The evolution of research perspectives reflects the developmental trajectory of residential mobility studies, which have successively encompassed the ecological school, spatial school, behavioral school, and structural school. Specifically, before the 1960s,

residential mobility research focused on placing humans within the ecological environment to analyze how family conditions, social status, and economic income influence residential location [18,19]. In the early 1960s, under the influence of the quantitative revolution, the focus shifted to the relationship between spatial characteristics and quantitative patterns of urban residential mobility, with scholars proposing that quantitative patterns determine urban spatial distribution [20,21]. Subsequently, under the influence of the behavioral revolution, research shifted again, this time to the relationship between the spatial characteristics of residential mobility and human behavioral patterns. This perspective highlights the role of individual personality and the human perception of external factors in influencing residential mobility [22,23]. By the 1970s, the focus of urban residential mobility research moved further from studying the relationship between human behavior and residential mobility to exploring the connection between human behavior and socio-economic structures. During this period, researchers proposed that class issues in capitalist societies are key factors affecting residential mobility [24]. Since the 21st century, under the influence of new cultural geography, research on residential mobility has increasingly started to focus on the social spaces of various social groups [25]. Scholars now integrate findings from sociology, political science, and anthropology into residential mobility studies, emphasizing the role of “values” in shaping residential mobility among different social groups [26]. In conclusion, the research perspectives on residential mobility continue to evolve, progressing through several key stages and exhibiting a diverse and multidimensional trend.

2.2. Spatio-Temporal Characteristics of Residential Mobility

Residential mobility represents a dynamic process that unfolds across both temporal and spatial dimensions. The spatio-temporal characteristics of residential mobility serve as the external manifestation of mobility behaviors and constitute the foundational step in residential mobility research. This area of research primarily focuses on the spatial attributes such as migration direction and distance, as well as temporal attributes including relocation timing and age-specific probability variations in mobility [27]. Divergent patterns emerge between Western societies and China in terms of migration rates, distances, and directions, reflecting differences in socioeconomic development levels and urbanization processes. Western societies generally exhibit higher population mobility, with metropolitan areas demonstrating more frequent relocation rates compared to smaller cities. The volume of new housing construction significantly influences migration rates across all periods [28]. With respect to the distance and direction of mobility, the probability of short-distance moves is higher than that of long-distance moves, residential mobility is particularly common within urban centers and newly developed suburban areas, the outward migration rate decreases from the urban center to the suburbs, and cross-districted residential mobility between urban centers and suburbs is relatively rare [29]. Notably, the primary direction of residential mobility is concentrated in a fan-shaped space from the urban center to the suburban areas [30]. In contrast, the migration rate in Chinese cities was relatively low before the 1970s. However, migration rates have gradually increased with urban development since then. Moreover, the marketization of housing has gradually had a more significant impact on the overall patterns of residential mobility in cities. In terms of the distance and direction of residential mobility, most moves occur over short distances within and between the central urban area, inner suburbs, and outer suburbs. Specifically, migration from the central urban area to the inner suburbs is the most active [31]. Furthermore, newly added urban populations show a trend toward suburbanization and decentralization. As a result, the main directions of residential mobility include movement from the

urban center to the urban periphery as well as from suburban areas to more urbanized regions [32].

2.3. Factors Influencing Residential Mobility

Building upon the analysis of spatio-temporal characteristics, this section investigates the intrinsic driving factors behind residential mobility. The examination of spatio-temporal features provides a crucial entry point for exploring these influencing factors, facilitating a better understanding of research priorities and the selection of relevant variables. The field of geography has conducted extensive research on the determinants of residential mobility, with scholars generally concurring that residential mobility results from the interplay of multiple factors [33]. Existing research in China tends to emphasize city-level factors, understanding residential location choices and spatial differentiation processes from a group perspective [27]. Scholars explain residential spatial differentiation based on factors such as income, family structure, occupation, and household registration natures (Hukou) [25,34]. Others analyze the main influencing factors of urban residents' residential location choices from perspectives such as job–housing spatial matching, urban spatial expansion, and housing characteristics [18]. Western studies predominantly approach the motivations for residential location choices from a micro-level individual perspective, focusing on variables related to individual and family life cycle factors. These studies emphasize the influence of individual life course trajectories, housing characteristics, and the accessibility of residential locations. Residential preferences and location choices vary significantly based on age, educational background, and life stage [34]. Factors such as age and the presence of children also play a crucial role in influencing residential mobility [35]. Housing characteristics, including property ownership, housing type, quality, and facilities, are critical considerations in migration decisions [36,37]. Additionally, the trade-offs residents make regarding accessibility to workplaces, public services, shopping venues, and recreational areas significantly impact residential mobility [38–40]. In contrast, existing research in China tends to focus more on city-level factors, analyzing residential location choices and spatial differentiation processes from a group perspective. These studies often explain the influencing factors of residential mobility through the lens of housing needs and consumption patterns among residents with different income levels, family structures, occupations, and household registration natures (Hukou).

2.4. Research Data and Methods on Residential Mobility

From the perspective of research methods and data, studies on residential mobility are conducted at both macro and micro levels. At the macro level, researchers rely on the push–pull theory [41] and use data such as official statistics and mobile phone signaling data to examine population migration and urban residential spatial restructuring [25,42–44]. In contrast, at the micro level, studies are often grounded in life cycle and life course theories. Researchers combine micro-survey data with quantitative methods, such as social network analysis, structural equation modeling, multinomial logistic regression, and exploratory factor analysis, to measure the behavioral characteristics and spatio-temporal distribution differences of residential mobility [45]. Notably, retrospective survey data provide more comprehensive individual information about migrants, including basic demographics such as age, gender, and household registration natures (Hukou). Additionally, these data also allow for a better understanding of housing details before and after relocation, such as changes in housing size and type, offering a rich foundation for analysis. Moreover, researchers distribute surveys through various online and offline channels to reach a broader population engaged in residential mobility.

Time geography represents a significant theory in human geography that emerged in the 1960s. This approach emphasizes incorporating both temporal and spatial dimensions into the study of human activities, breaking away from traditional static analysis models. Its spatio-temporal path method constructs the trajectories of individuals' movements in space and time, visually presenting people's activity sequences and states in specific spaces at different time points. Residential mobility is fundamentally a spatio-temporal behavior [46]. The spatio-temporal path analysis approach offers distinct advantages for studying residential mobility by enabling continuous tracking of individual migration trajectories and multidimensional representation of mobility characteristics. Additionally, its strong visualization capacity clearly displays both differences and commonalities in mobility patterns across individuals and groups. Cross-sectional studies of residential mobility can only capture spatial characteristics at specific time points, failing to reflect behavioral patterns of individuals or groups across different periods [32,47]. When analyzing NECGs' residential mobility, the spatio-temporal trajectory method from time geography overcomes these limitations by continuously tracking individual migration paths. This approach reveals multiple dimensions of residential mobility, including frequency, distance, direction, spatial clustering patterns, and critical temporal nodes. The method avoids the constraints of single-dimensional analysis and provides a clearer understanding of the spatial and temporal characteristics of NECGs' urban mobility patterns. It accurately captures graduates' residential space transitions at different stages, offering a unique and effective perspective for examining both the spatio-temporal features of their migration behavior and its underlying influencing factors. This approach helps uncover dynamic relationships often overlooked in traditional studies and enhances our comprehensive understanding of residential mobility phenomena.

In summary, existing research on residential mobility has achieved notable results, with studies examining migration patterns and influencing factors from various perspectives. However, significant research gaps remain in applying the spatio-temporal path method from time geography to thoroughly analyze the spatio-temporal dynamics of residential mobility among NECGs. Current studies predominantly focus on static characteristic descriptions or single-factor analyses, making it difficult to comprehensively capture the complex and dynamic residential mobility processes of graduates during their early career stages.

3. Materials and Methods

This study adopts a behavioral micro-perspective on residential mobility, utilizing data from the "Guangzhou New Residents Residential Mobility Survey" to examine the growing and increasingly differentiated NECG population within the city. Applying the spatio-temporal path analysis method from time geography, the study presents detailed information on the spatial characteristics of NECGs' residential mobility in Guangzhou, including origins, destinations, migration distance, and direction, as well as temporal characteristics such as migration frequency, timing, and probability. This approach clearly illustrates the mobility patterns of residential migration. Building on insights from spatio-temporal trajectory analysis and integrating Western theoretical frameworks with China's specific context, this study employs multinomial logistic regression to analyze the influence of life course attributes, housing attributes, accessibility, and socioeconomic attributes on residential mobility, aiming to uncover the underlying patterns and mechanisms of NECGs' residential mobility. The main structure of the analytical framework appears in Figure 1.

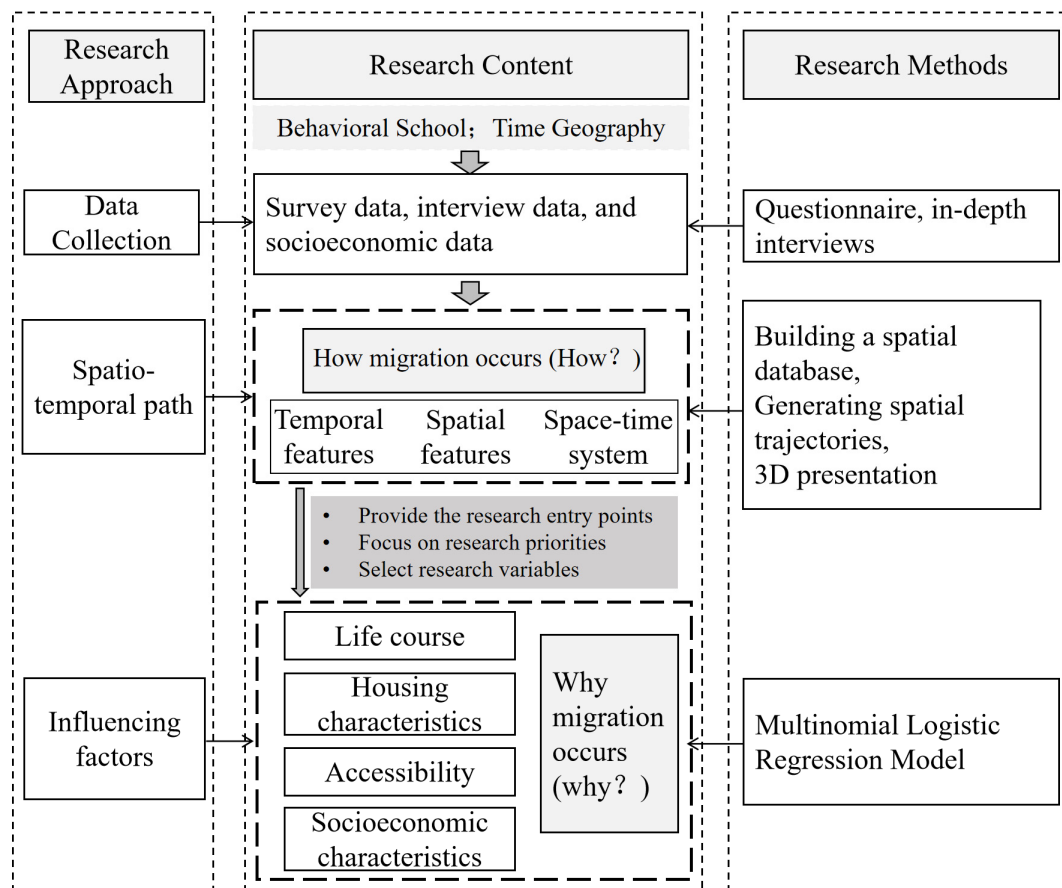


Figure 1. Research framework.

3.1. Study Area

Guangzhou, which is located in South China and is part of the Guangdong-Hong Kong-Macao Greater Bay Area, serves as the capital of Guangdong Province. It is a sub-provincial city, a national central city, and a megacity. Specifically, the city governs 11 districts, including the four central urban districts—Tianhe, Liwan, Haizhu, and Yuexiu—and the seven peripheral districts—Baiyun, Huangpu, Huadu, Panyu, Conghua, Nansha, and Zengcheng. Guangzhou covers a total area of approximately 7434.40 square kilometers and has a population of 18.827 million.

First, as a first-tier city, Guangzhou has a developed economy and a diverse industrial structure that not only provides numerous employment opportunities but also attracts a large number of NECGs each year. Second, Guangzhou's housing market is both complex and representative. On one hand, the central urban areas face challenges such as high housing prices and limited housing availability, while on the other hand, the peripheral districts offer varying levels of housing supply and supporting infrastructure. Third, the "14th Five-Year Plan for Housing Development in Guangzhou" clearly outlines the spatial layout of the central and peripheral areas. This plan, therefore, provides a foundation for exploring the impact of different regions on the residential mobility of NECGs and serves as an ideal case study for urban housing research. For these reasons, this study selects Guangzhou as the study area to investigate the residential mobility of NECGs, as shown in Figure 2.

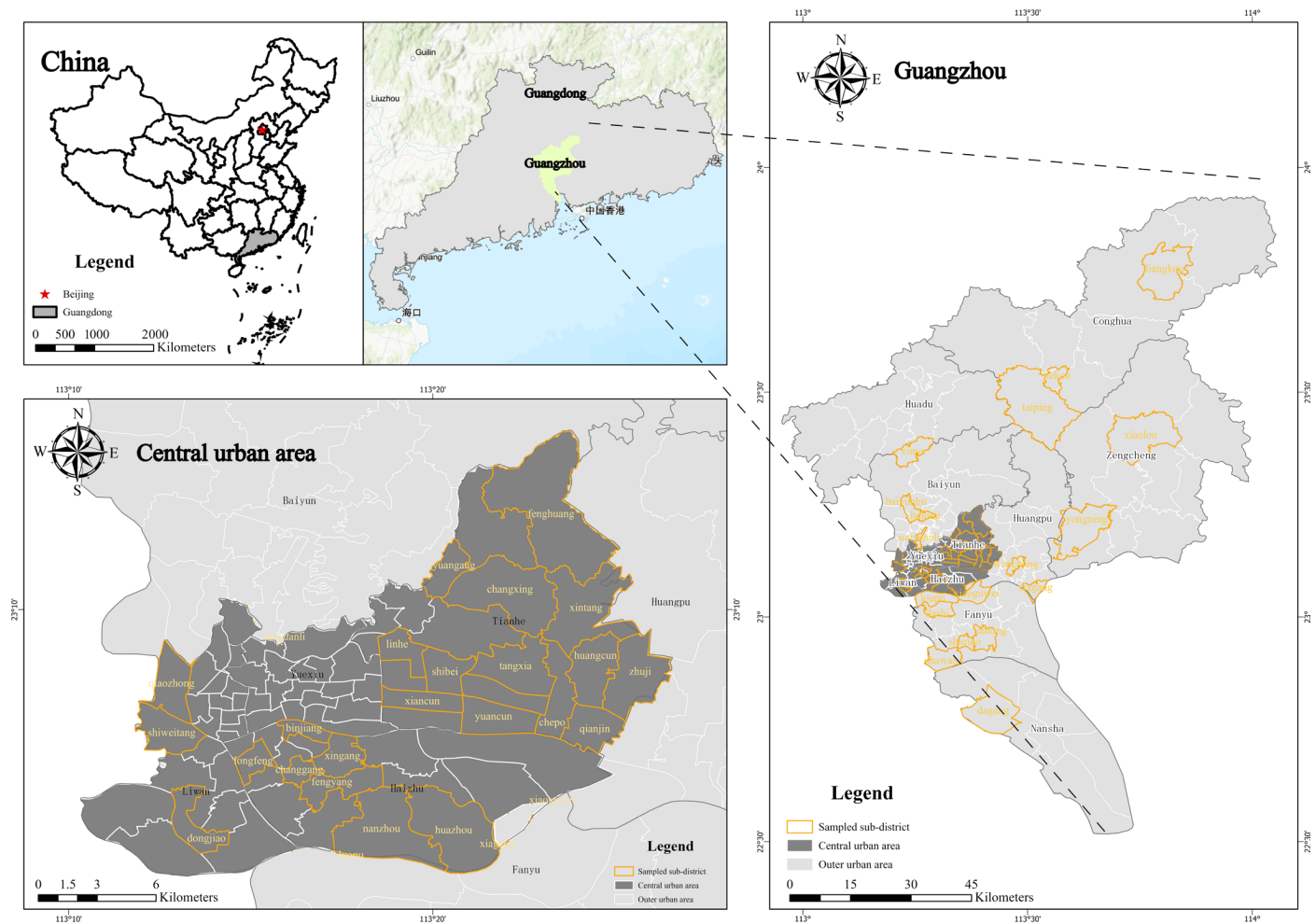


Figure 2. Location of study area.

3.2. Study Data

This study employs retrospective survey data and in-depth interview data. The questionnaire design consists of three main sections: basic personal and family information, current living conditions, and past residential experiences. The survey covers the social attributes, family attributes, economic attributes, and housing attributes of NECGs, as well as their residential mobility in Guangzhou from 2010 to 2024. The research activities and questionnaire content are submitted to the Institutional Review Board of the School of Geography and Planning at Sun Yat-sen University for review and approval. The data collection method is determined by the characteristics of the research subjects and is conducted both online and offline. Online data collection primarily utilizes the “Wenjuanxing” survey platform www.wjx.cn (accessed on 25 August 2024), which incorporates logical skip patterns and mandatory fields. The distribution of the questionnaire is carried out in three ways: first, by contacting career office administrators at various universities and leveraging alumni resources of recent graduates employed in Guangzhou. The surveyed universities include undergraduate institutions such as Sun Yat-sen University, South China Agricultural University, Guangzhou University, Guangdong University of Technology, and Guangzhou City University of Technology, as well as vocational colleges (college diploma) like Guangdong Communication Polytechnic, Guangzhou Panyu Polytechnic, Guangdong Construction Polytechnic, and Guangzhou City Construction College. Second, questionnaire invitations are distributed to NECGs through social media platforms such as WeChat and Weibo. Third, based on the hiring trends during graduation seasons at various universities, companies with high graduate employment rates are identified to gain access

to survey channels. Questionnaires are distributed to new employees through internal communication channels of these companies, including Ping An Property & Casualty Insurance Company of China, Guangzhou Automobile Group Co., Ltd., and SHEIN International Import & Export Co., Ltd. (Guangzhou, China). Offline data collection employs a combination of regional quota sampling and random sampling. Sampling locations are determined based on the proportion of the permanent population in the surveyed areas in 2022. Peripheral urban areas, with fewer population clusters compared to central urban areas, have fewer sampling points. A quota framework is established according to the permanent population size of each district. Between June 2023 and June 2024, representative locations with high resident density are selected across various districts in Guangzhou (ensuring sample dispersion across districts). Random sampling surveys are conducted among college graduates who have been steadily employed in Guangzhou within the past five years, following the quota framework. Offline surveyors are trained to strictly adhere to procedures and standards, ensuring consistency and accuracy in data collection. Table 1 presents the number of questionnaires collected through various sampling methods. As a crucial component of qualitative research [47], the in-depth interview data come from semi-structured, thorough conversations with respondents. The interviews primarily focus on NECGs' residential mobility trajectories, the motivations behind their migration decisions, and their adaptability to the residential environments.

Table 1. Number of Questionnaires Collected Through Different Methods.

Sampling Method	Specific Channels	Frequency
Online	University career centers and alumni networks in Guangzhou	129
	Social media platforms such as WeChat and Weibo	93
	Internal communication channels of enterprises	121
Offline	Residential areas with high concentrations of NECGs	201
	High-density commercial centers	149
	Large-scale job fairs in Guangzhou	69

The study distributes over 1000 questionnaires both online and offline, collecting 762 valid responses with complete information. Table 2 presents the basic characteristics of the survey sample. The data reveal a balanced gender distribution among respondents. Based on educational attainment, the sample divides into three categories: vocational college, undergraduate, and postgraduate or higher. Undergraduate respondents constitute the largest proportion, followed by vocational college respondents, while postgraduate respondents represent the smallest group. In particular, NECGs, due to their younger age, have a lower likelihood of being household heads or spouses, resulting in a lower overall representation in the sample. Moreover, most respondents report being unmarried. The questionnaire also collects information on respondents' household registration natures (Hukou) to distinguish between "new Guangzhou residents" and "migrant populations". The results indicate that approximately 46.9% are new Guangzhou residents, while 53.1% are migrant populations without registered household status in Guangzhou. In terms of employment status, 62.9% of respondents work full-time, 17.0% are flexibly employed, and 9.1% have never been employed. Regarding monthly income, about half of the respondents earn between CNY 5000 and 10,000. The survey also finds that 12.6% of respondents own housing with property rights. From the perspective of residential location, 46.66% of respondents live in central urban areas, while 53.34% reside in peripheral districts. Among the sample, 326 respondents report having experienced residential mobility, primarily involving one relocation event, with a total of 390 relocation incidents recorded.

Table 2. Sample profile.

Attributes		Categories	Full Sample (N = 762)		2024 Guangdong Graduate Population Data	
			Frequency	Proportion (%)	Proportion (%)	
Life Course Attributes	Gender	Male	386	50.7	51.1	
		Female	376	49.3	48.9	
	Marital Status	Married	130	17.1	—	
		Unmarried/Others	632	82.9	—	
	Number of Children	0	562	73.7	—	
		1	122	16.0	—	
2 or More		78	10.3	—		
Housing Attributes	Housing Ownership	Owner-occupied	96	12.6	—	
		Rental	428	56.2	—	
		Others	238	31.2	—	
	Housing Type	Commercial Housing	278	36.5	—	
		Others	484	63.5	—	
	Living Area	0–10 m ²	168	22.1	—	
		10–20 m ²	175	22.9	—	
		20–50 m ²	276	36.2	—	
		50 m ² or Above	143	18.8	—	
	Residential Location	Central Urban Area	356	46.7	43.2	
		Suburban Area	408	53.3	56.8	
	Accessibility Attributes	Commuting Time	0–30 min	422	55.4	—
30–60 min			175	23.0	—	
60 min or Above			165	21.6	—	
Commuting Costs		CNY 0–500	378	49.6	—	
		CNY 500–1000	292	38.3	—	
		CNY 1000 or More	92	12.1	—	
Socioeconomic Attributes	Household Registration	Guangzhou Hukou	358	46.9	—	
		Non-Guangzhou Hukou	404	53.1	—	
	Educational Level	Associate degree	258	33.9	37.2	
		Bachelor’s degree	376	49.3	48.5	
		Postgraduate or higher	128	16.8	14.3	
	Type of Institution	Science/Engineering/Agriculture/Medicine	166	21.8	18.8	
		Teacher Education/Finance/Law/Political Science	72	9.5	8.3	
		Ethnic Studies/Language/Arts	110	14.4	15.8	
		Comprehensive	414	54.3	57.1	
	Employment Status	Full-time Employment	480	62.9	—	
		Flexible Employment	130	17.0	—	
		Never Employed	70	9.1	—	
		Other	82	11.0	—	
	Monthly Income	CNY 0–5000	154	20.1	—	
		CNY 5000–10,000	384	50.2	—	
		CNY 10,000 or More	232	29.7	—	
	Number of Residential Mobility Occurrences	Number of Residential Mobility Occurrences	0 Times	436	57.2	—
			1 Time	270	35.5	—
2 or More Times			56	7.3	—	

Note: The data come from the author's questionnaire survey results. The symbol “—” indicates that the 2024 Guangdong graduate population data do not contain matching information for certain survey data items; therefore, those specific comparisons are not conducted.

The retrospective survey data, while effective for obtaining historical residential mobility information, inevitably contain potential biases. As memory decays over time, respondents may experience information gaps, vague details, or subjective reconstruction, leading to reduced accuracy in recording key temporal nodes and residential locations. A comparison between the sample quotas of this survey and the relevant characteristics of the 2024 college graduate population in Guangdong Province shows that the proportions of gender, household registration nature, educational level, and type of graduating institution generally align, indicating that the sampled group in this study holds a certain degree of representativeness.

3.3. Study Method

3.3.1. Spatio-Temporal Path Visualization

Time geography, as an analytical method for studying individual behavioral activities, provides a theoretical framework for constructing these activities within continuous space and time [48]. Specifically, the trajectory data of residential mobility among NECGs integrates the temporal and spatial dimensions of relocation behavior. To achieve a comprehensive analysis, the expression of these trajectories should be based within a spatio-temporal environment to fully reflect the patterns of spatio-temporal changes in relocation activities. In this context, combining time geography with GIS provides an efficient environment for data representation and analysis in the study of relocation trajectories [49,50]. Fundamentally, the spatio-temporal system can be seen as a product of integrating demographic lifelines with geographic space. A lifeline refers to the continuous representation of an individual's life on a one-dimensional time axis. By extending this concept, incorporating two-dimensional geographic space into the lifeline enables individual activities to be continuously represented in a three-dimensional spatio-temporal environment, which is known as the spatio-temporal system. As shown in Figure 3a, the spatio-temporal system is a three-dimensional orthogonal system, consisting of a two-dimensional spatial plane (x, y) and a one-dimensional time axis (t) perpendicular to it. In this representation, the two-dimensional space reflects changes in the spatial position of individual activities, while the one-dimensional time axis captures the temporal sequence of these activities. Thus, the spatio-temporal system provides an intuitive and effective environment for representing and analyzing individual behaviors within continuous time and space [51]. Within a spatio-temporal path, vertical line segments indicate no spatial movement over a period of time, while diagonal line segments represent spatial displacement [52]. In practical terms, vertical line segments correspond to an individual's residence at a specific location, and diagonal line segments reflect residential mobility activities. As a result, the spatio-temporal path effectively represents the relocation trajectories of individuals, making spatio-temporal paths and spatio-temporal systems the optimal methods for visualizing these trajectories [53,54]. To illustrate, Figure 3b presents an example of a residential mobility spatio-temporal path. In this example, if an individual's residence remains unchanged, the spatio-temporal path appears as a vertical line segment perpendicular to the map. However, when residential mobility occurs, the spatio-temporal path is expressed as a horizontal line parallel to the map. More specifically, the individual's residential experience begins at their first residence from birth and involves two relocations in sequence.

Based on the theoretical framework of time geography, we establish an expression and analysis environment for mining the residential mobility trajectories of NECGs. This environment is implemented in a prototype system, which offers functionalities such as trajectory data management, query, visualization, and analysis [51]. ArcGIS Engine, a secondary development component package introduced by ESRI for creating new applications, provides the `axSceneControl` scene control for displaying and navigating three-dimensional

graphics [55]. In the axSceneControl scene, the three dimensions represent longitude, latitude, and altitude (x, y, z) in geographic space. By replacing the altitude z with time t , the three-dimensional geographic space transforms into a three-dimensional spatio-temporal scene, representing longitude, latitude, and time (x, y, t).

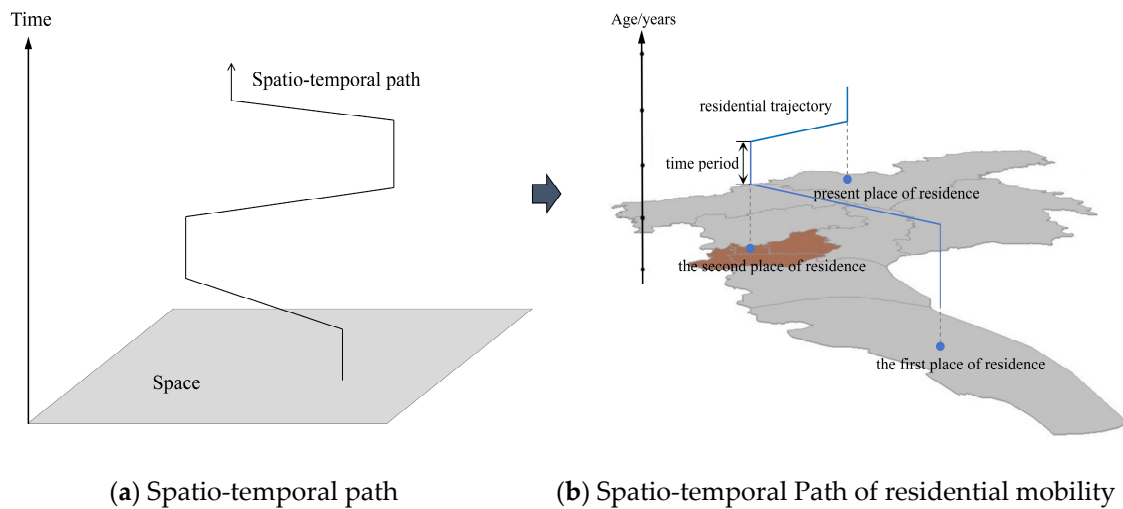


Figure 3. Space–time system and spatio-temporal path of time geography.

The implementation of the spatio-temporal path of residential mobility consists of trajectory points and trajectory paths. In practice, trajectory points are created in ArcGIS as three-dimensional-type points using the longitude, latitude, and timestamp information obtained from the database. These points are added to the axSceneControl scene using the Add Element method provided by the axScene-Control scene control to visualize the trajectory points. The trajectory path connects adjacent trajectory points, recording the movement of individuals between them. An individual's trajectory remains continuous in both time and space. Whether connecting the trajectory points into a spatio-temporal path or re-labeling the path using dynamic segmentation, the process requires interpolation of known trajectory points to estimate the coordinates of other points. Linear interpolation, spline interpolation, or Bézier curves, among other methods, serve as options for estimating trajectory points. However, regardless of the interpolation method, these approaches only simulate and approximate real conditions. The actual trajectory of individual activities depends on the collection of individual activity data.

The basic steps for processing residential mobility data of NECGs can be divided into three main stages: establishing the spatio-temporal database, generating and analyzing spatio-temporal paths, and creating three-dimensional visualizations.

1. Establishing the spatio-temporal database: In time geography, all human activities are considered behaviors that occur within specific spatial and temporal ranges. As such, the spatio-temporal database for residential mobility must include both the basic attributes of individuals and the spatial coordinates associated with their migration process. To represent these processes effectively, specific migration paths are depicted using straight-line distances.
2. Generating and analyzing spatio-temporal paths: In this stage, three-dimensional GIS analysis tools are combined with the Space Time Path analysis plugin to generate spatio-temporal path curves for residential mobility. Subsequently, attribute calculation tools are used to measure the length of migration paths and calculate the central coordinates of migration locations for each time group. This enables a detailed analysis of migration trends across different life stages.

3. Three-dimensional visualization: Using the ArcScene module in GIS, the study visualizes spatio-temporal path curves, with time serving as the time coordinate. This step facilitates the analysis of residential mobility path characteristics across different time stages, providing an intuitive understanding of the data.

3.3.2. Variable Selection and Model Construction for Residential Mobility

The dependent variable in this study is the locational change of residential mobility, classified into four types: ① residing within the central urban area both before and after relocation (central urban area to central urban area), ② residing in the central urban area before relocation and in the peripheral urban area after relocation (central urban area to peripheral urban area), ③ residing in the peripheral urban area before relocation and in the central urban area after relocation (peripheral urban area to central urban area), and ④ residing in the peripheral urban area both before and after relocation (peripheral urban area to peripheral urban area). Studies at the individual micro-level focus on the motivations behind residential location choices, with selected independent variables centered on individual and family life cycle factors. These studies emphasize the influence of life course attributes, housing characteristics, and residential location accessibility [56–58]. In our survey, we find that the socioeconomic attributes of NECGs, such as educational level and monthly income, also significantly impact their residential mobility location choices. Based on the analytical framework established earlier and data availability, this study selects variables encompassing life course attributes, housing attributes, accessibility attributes, and socioeconomic attributes. Specifically, life course attributes include gender, marital status, and age. Housing attributes include changes in housing ownership, housing type, changes in living area, changes in commercial facilities, changes in educational resources, and changes in medical facilities. Accessibility attributes include changes in commuting time, changes in commuting costs, and changes in commuting distance. Socioeconomic attributes include household registration nature (Hukou), educational level, discipline category, job type, monthly income, length of residence in Guangzhou, and employer type.

The dependent variable in this study includes four types of locational change and belongs to an unordered multi-categorical variable. Although spatial regression methods such as spatial lag models can address spatial autocorrelation in mobility patterns, they require highly demanding data conditions, including precise and complete spatial coordinates and carefully constructed spatial weight matrices. Given that this study focuses on the influence mechanisms of multiple dimensions—housing attributes, accessibility, socioeconomic attributes, and life course attributes—on the locational changes of residential mobility among NECGs in Guangzhou, the multinomial logistic regression model proves suitable. It effectively handles multi-categorical dependent variables and clearly presents the associations between influencing factors and types of locational change, aligning well with the exploratory nature of this research. The dependent variable comprises the four types of locational changes, with “residing within the central urban area both before and after relocation (central urban area to central urban area)” serving as the reference group, denoted as “C”. The other three types of locational changes are denoted as “j”. The likelihood ratio of the locational change of the j -th category to that of the reference group (C) conforms to the following linear equation:

$$\ln\left(\frac{P(y = j|X)}{P(y = C|X)}\right) = \alpha_j + \sum_{i=1}^n \beta_{ji}x_i \quad (1)$$

The probability of the occurrence of the j -th type of locational change is expressed as follows:

$$P(y = j|X) = \frac{\exp(\alpha_j + \sum_{i=1}^n \beta_j x_i)}{1 + \sum_{j=1}^{C-1} \exp(\alpha_j + \sum_{i=1}^n \beta_j x_i)} \quad (2)$$

where α_j is the constant term regression coefficient, x_i denotes the independent variables introduced into the model, which primarily include housing characteristics, accessibility, socioeconomic attributes, life course characteristics, and other related variables, and β_{ji} is the coefficient of the independent variable x_i .

4. Results

4.1. Spatio-Temporal Paths of Residential Mobility Among NECGs in Guangzhou

Figure 4 illustrates the changes in the residential mobility paths of NECGs. Overall, the residential mobility of NECGs primarily involves cross-district mobility, while intra-district moves are relatively less common. At the cross-district level, residential mobility spans all 11 districts, and no significant trend of suburbanization or migration to peripheral districts is evident. However, at the district scale, Panyu District in the peripheral areas and Yuexiu District in the central areas exhibit the largest proportions of inflow and outflow. In particular, the most prominent relocation paths are those from Panyu District to Yuexiu District and from Liwan District to Zengcheng District (Figure 4a). At the sub-district scale, Su She sub-district and Xin Jiao sub-district in the central areas, as well as Huangpu sub-district in the peripheral areas, demonstrate the largest proportions of inflow and outflow (Figure 4b).

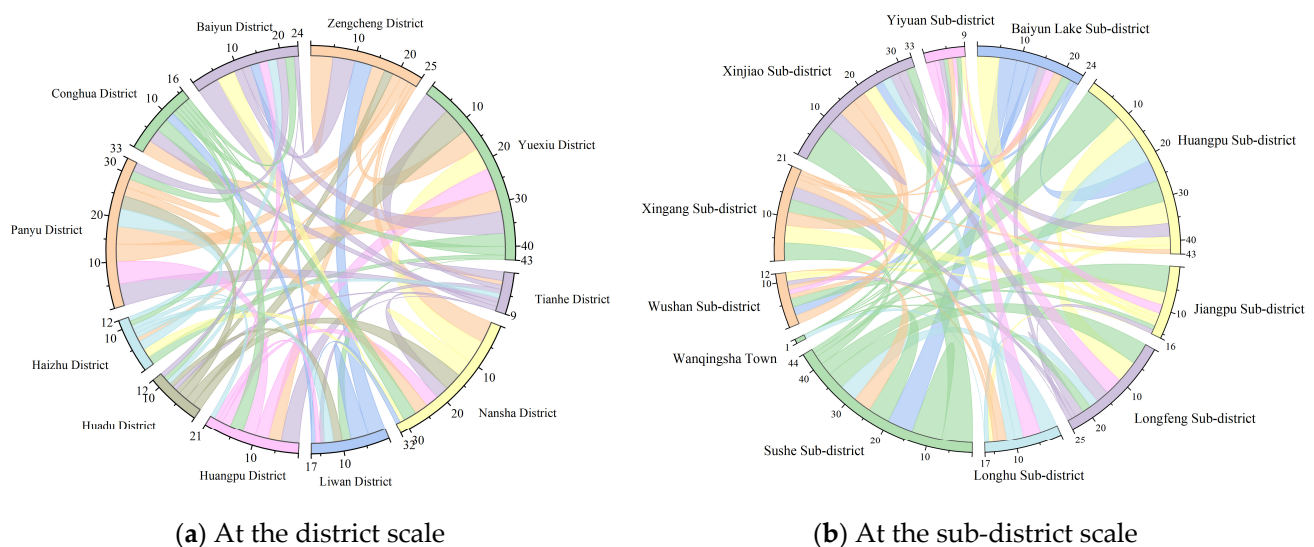


Figure 4. The residential migration flow path of NECGs in Guangzhou.

Figure 5 more clearly illustrates the cross-district migration flows of individuals with different educational levels in Guangzhou. It reveals that the migration directions of NECGs with associate degree are relatively dispersed. Outwardly, they predominantly move from central urban areas to surrounding regions with lower housing prices and living costs, such as from Tianhe District to Baiyun District (5.16%) and Haizhu District to Panyu District (4.15%). Inwardly, they migrate from the urban fringe to sub-central areas, such as from Nansha District to Haizhu District (2.77%) and Panyu District to Huangpu District (2.06%). From a life course perspective, individuals with associate degrees may initially earn lower salaries, making them more inclined to choose residential areas with lower rents. Considering accessibility factors, their jobs may be distributed

across various urban areas, allowing for relatively flexible commuting distances and times, which contributes to the diversity in their residential choices. In contrast, individuals with bachelor's degrees tend to migrate outward from core urban areas to well-developed and well-equipped surrounding regions, such as from Yuexiu District and Haizhu District to Panyu District (2.99%), Huangpu District (2.11%), and Baiyun District (1.77%). Inwardly, they move from remote peripheral districts to central urban areas or mature sub-central regions, such as from Conghua District to Tianhe District (1.23%). This reflects their higher pursuit of employment opportunities and quality of life. On one hand, they are more inclined toward the abundant employment resources in core urban areas for career development. On the other hand, as urban development progresses, the improving infrastructure in surrounding areas also attracts some bachelor's degree holders. This not only highlights the importance of career development in their life course but also demonstrates the influence of housing characteristics and accessibility on their residential choices. Individuals with postgraduate's degrees or higher primarily exhibit a migration trend from central urban areas to peripheral districts, such as from Haizhu District to Panyu District (6.35%) and Yuexiu District and Huangpu District (4.25%). This phenomenon is closely related to their career development and housing needs. Highly educated individuals are often concentrated in high-end industries and research fields, which shapes their migration patterns.

Figure 6 illustrates the cross-district residential mobility paths of NECGs who have either obtained Guangzhou household registration (Hukou) or not. It is evident that those who have successfully registered in Guangzhou exhibit shorter residential mobility distances. Their residential locations before and after relocation are predominantly concentrated in the central urban areas and the regions immediately adjacent to them. However, a significant number also migrate to suburban areas, particularly to Conghua, Nansha, and Huangpu districts. Data indicate that the top three districts of origin for these with Guangzhou Hukou are Panyu, Yuexiu, and Haizhu, while the primary destinations are Huangpu, Haizhu, and Liwan districts. In contrast, NECGs with non-Guangzhou Hukou demonstrate longer residential mobility distances and more dispersed location distributions before and after relocation. Their main districts of origin are Conghua, Tianhe, and Panyu, with Tianhe, Baiyun, and the outer suburban Haizhu districts serving as the primary destinations.

By integrating the time axis with spatial paths, we reveal the dynamic migration behaviors of NECGs in Guangzhou in a more multidimensional manner. Building on the analysis of planar spatial paths, Figures 7–9 further introduce the time dimension to explore the temporal paths and three-dimensional spatio-temporal trajectories of residential mobility among NECGs with different educational levels and household registration (Hukou) types in Guangzhou.

Figure 7 illustrates the temporal distribution of residential mobility among NECGs after arriving in Guangzhou. Overall, the probability of residential mobility decreases over time, which further confirms the existing academic understanding that the probability of residential mobility decreases over time during the early stage of career development [23,54]. By combining the directions of cross-district migration, we observe that graduates with associate degrees exhibit a more dispersed distribution of migration points, without significant clustering in any specific region. As their duration in Guangzhou increases, the likelihood of residential mobility gradually decreases, with similar probabilities of relocation in the first two years of employment. Graduates with bachelor's degrees also show a relatively dispersed distribution, with higher probabilities of residential mobility in the first and second years after arriving in Guangzhou. Graduates with postgraduate or

higher qualifications are more likely to experience residential mobility in the early stages of employment, with a noticeable degree of clustering.

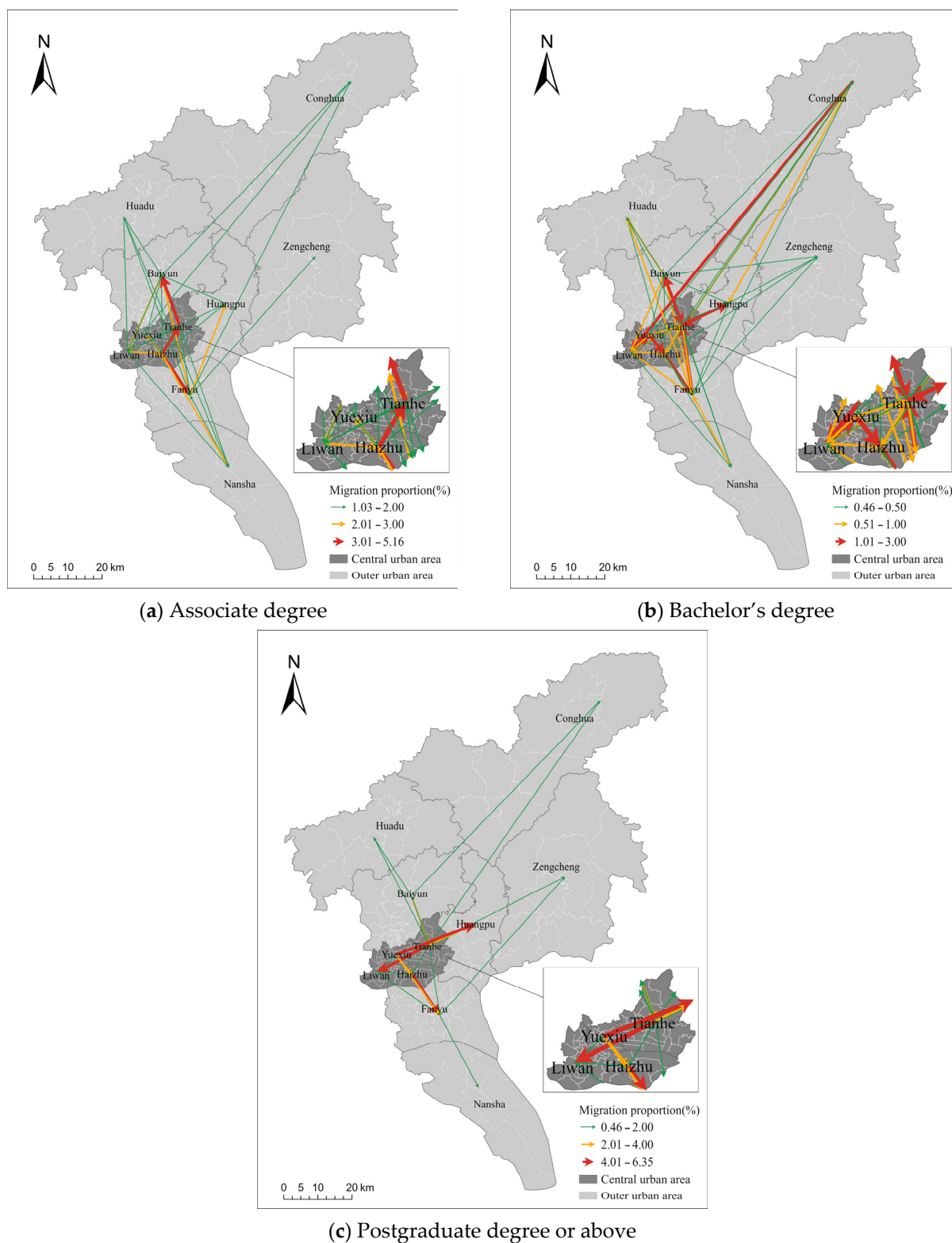


Figure 5. The cross-district migration flow of NECGs with different educational backgrounds.

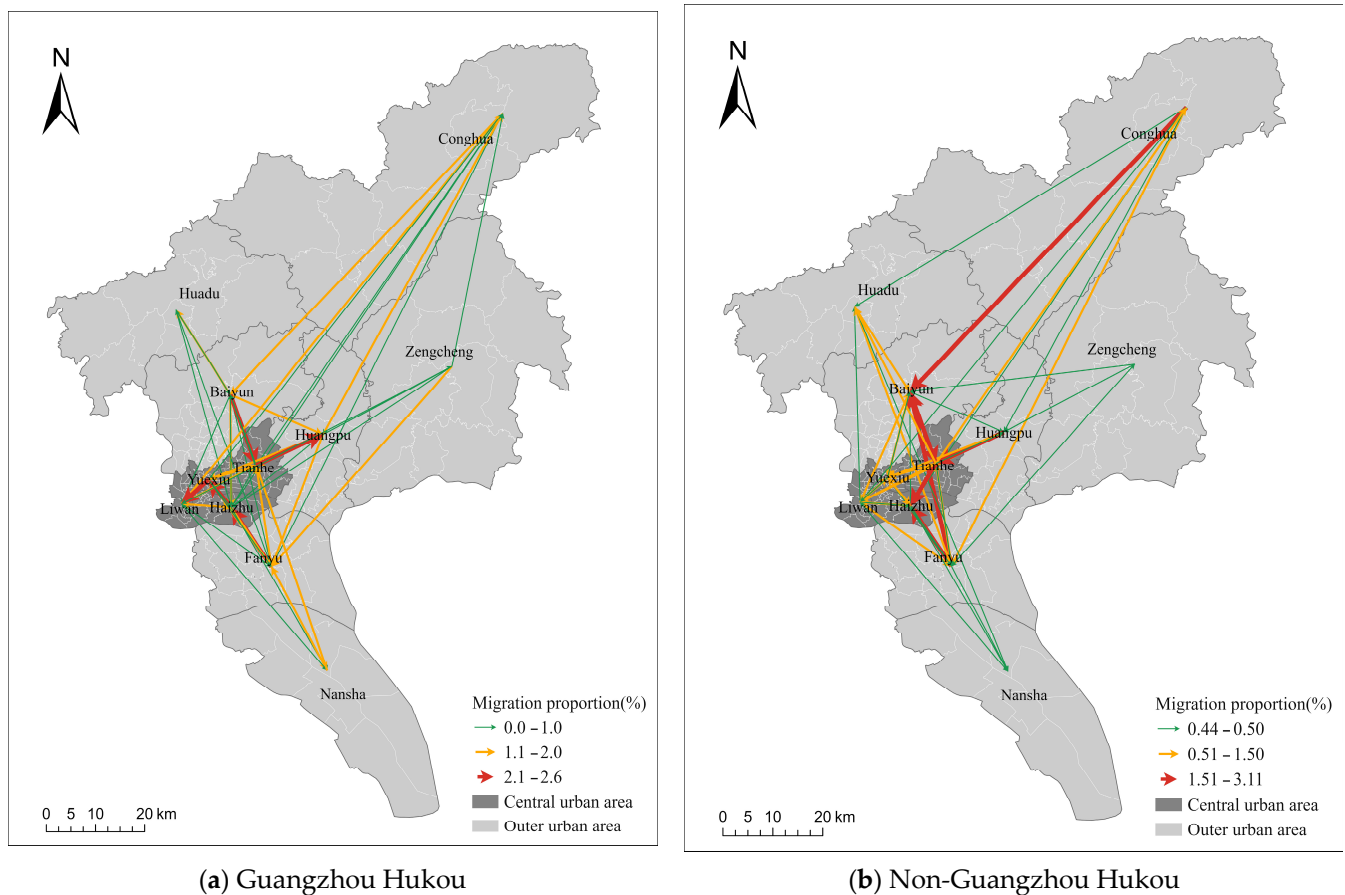
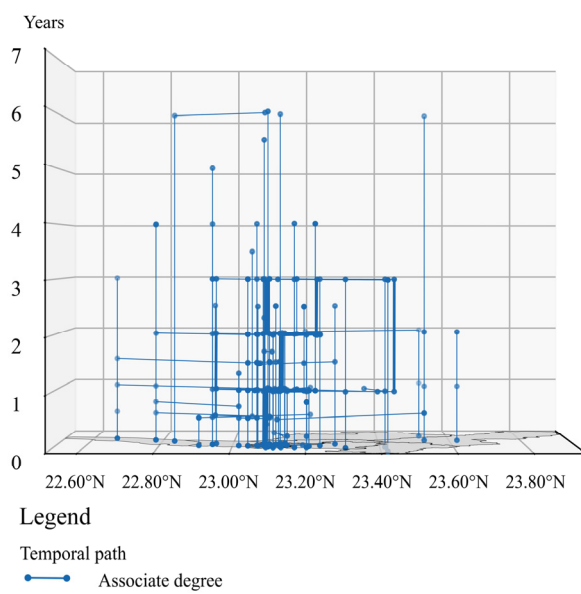


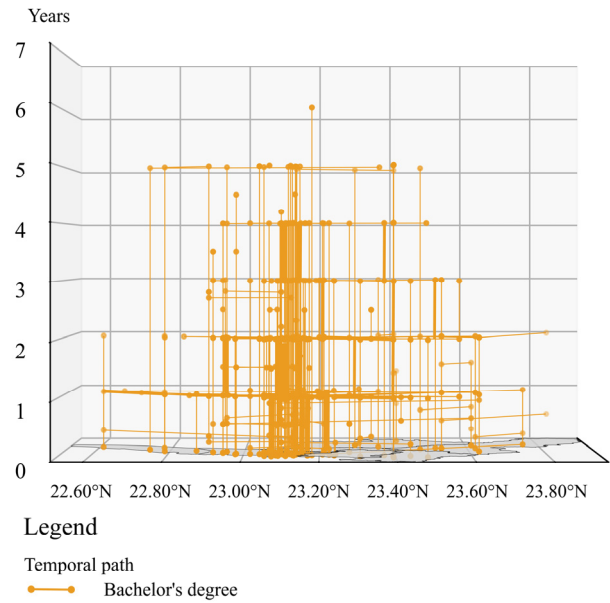
Figure 6. The cross-district migration flow of NECGs with different household registrations.

Figure 8 illustrates the temporal distribution of residential mobility among NECGs with different household registration (Hukou) types after arriving in Guangzhou. For graduates with Guangzhou Hukou, residential mobility tends to concentrate between the second and fourth years of employment. This may be because, after obtaining local household registration (Hukou), they need some time to adapt to the new environment and stabilize their work. As their careers progress, they develop clearer demands for personal development and quality of life, leading to a greater tendency to adjust their residential locations during this period to meet various needs such as work commutes and living amenities. In contrast, graduates with non-Guangzhou Hukou exhibit a more dispersed distribution of residential mobility, with a noticeable increase in relocation probability between the third and fourth years of employment. This reflects the fact that their residential choices are influenced by a wider range of factors. Without the constraints and ties of local household registration (Hukou), their residential decisions may rely more on considerations such as rental costs and the flexibility of workplace locations.

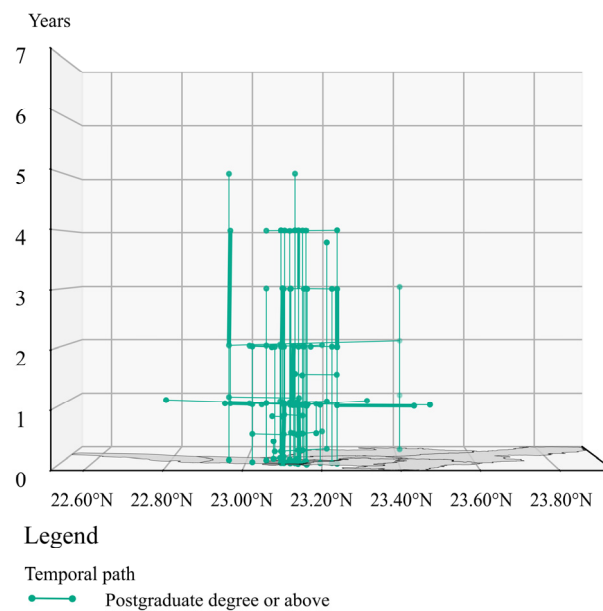
By compressing Guangzhou's geographical space into a two-dimensional plane and using the z-axis to represent “year-since-arriving in Guangzhou”, we construct a three-dimensional residential trajectory map. The results, as shown in Figure 9, illustrate the spatio-temporal paths of residential mobility at the sub-district scale among NECGs in Guangzhou, categorized by educational level and household registration type.



(a) Associate degree



(b) Bachelor's degree



(c) Postgraduate degree or above

Figure 7. Residential mobility time paths of NECGs with different educational backgrounds. ((a–c) represent the temporal residential mobility paths of the three groups with associate degree, bachelor's degree, and postgraduate or higher degrees, respectively).

As depicted in Figure 9a, in the dynamic relationship between time and space, as the duration in Guangzhou increases, NECGs across all educational levels exhibit a certain degree of spatial dispersion. The spatio-temporal paths of residential mobility differ among graduates with different educational backgrounds, which is closely related to the housing market institutional environment, urban spatial structure, and job types associated with different educational levels. The relocation rate for graduates with associate degrees is slightly higher than that for those with postgraduate or higher qualifications, a finding that contrasts with the trend observed among local residents in Guangzhou, where higher educational levels correlate with higher relocation probabilities [6,55]. Over time, some graduates with associate degrees migrate from peripheral urban areas to the edges of

central urban areas. Graduates with bachelor's degrees show more frequent mobility between central and peripheral urban areas as their duration in Guangzhou increases. Graduates with postgraduate or higher qualifications initially concentrate in central urban areas and gradually expand to high-potential peripheral areas over time. As shown in Figure 9b, the spatio-temporal paths of residential mobility also differ between NECGs with Guangzhou Hukou and those with non-Guangzhou Hukou. Compared to graduates with non-Guangzhou Hukou, those with Guangzhou Hukou exhibit more concentrated migration directions, indicating that household registration (Hukou) provides them with a sense of stability and belonging, making them more willing to develop long-term in relatively familiar and resource-rich areas. In contrast, graduates with non-Guangzhou Hukou show more active residential mobility over time, with some temporarily moving from peripheral to central urban areas before relocating again. This phenomenon may stem from the greater uncertainties they face in their employment, necessitating frequent adjustments to their residential locations to meet their evolving development needs.

By analyzing the spatio-temporal paths of residential mobility among NECGs in Guangzhou, the study finds that their residential location changes primarily involve cross-district migration. The majority of relocations occur within the first three years after arriving in Guangzhou, and the probability of further residential mobility decreases over time. The locational choices and frequency of residential mobility vary among graduates with different educational levels and household registration types. Specifically, higher educational attainment correlates with lower relocation rates, while non-registered graduates exhibit higher relocation rates compared to their registered counterparts. These differences likely stem from a combination of factors, including individual life trajectories, housing policies, accessibility, and socioeconomic conditions. Understanding the spatio-temporal characteristics of residential mobility among NECGs with varying educational levels and household registration natures (Hukou) provides valuable insights for further exploring the influencing factors behind their migration behaviors.

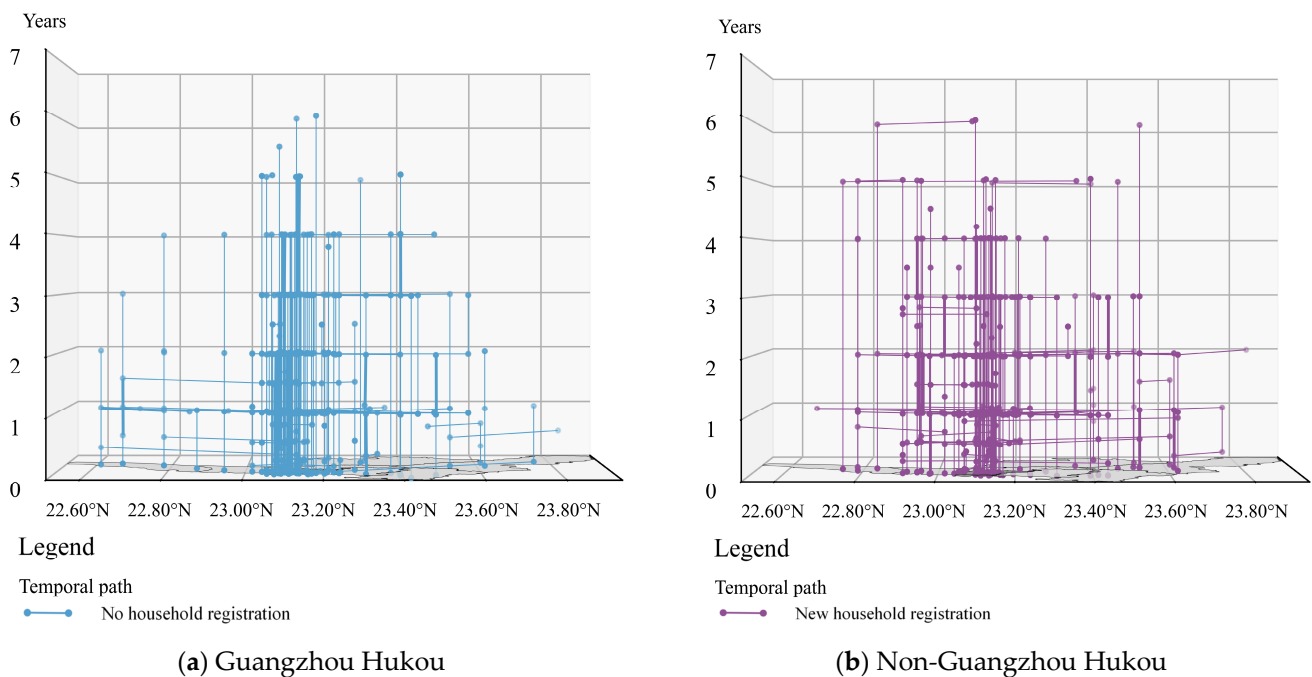


Figure 8. Residential mobility time paths of NECGs with different household registration types after arriving in Guangzhou. ((a,b) represent the temporal residential mobility paths of the two groups with Guangzhou Hukou and Non-Guangzhou Hukou, respectively).

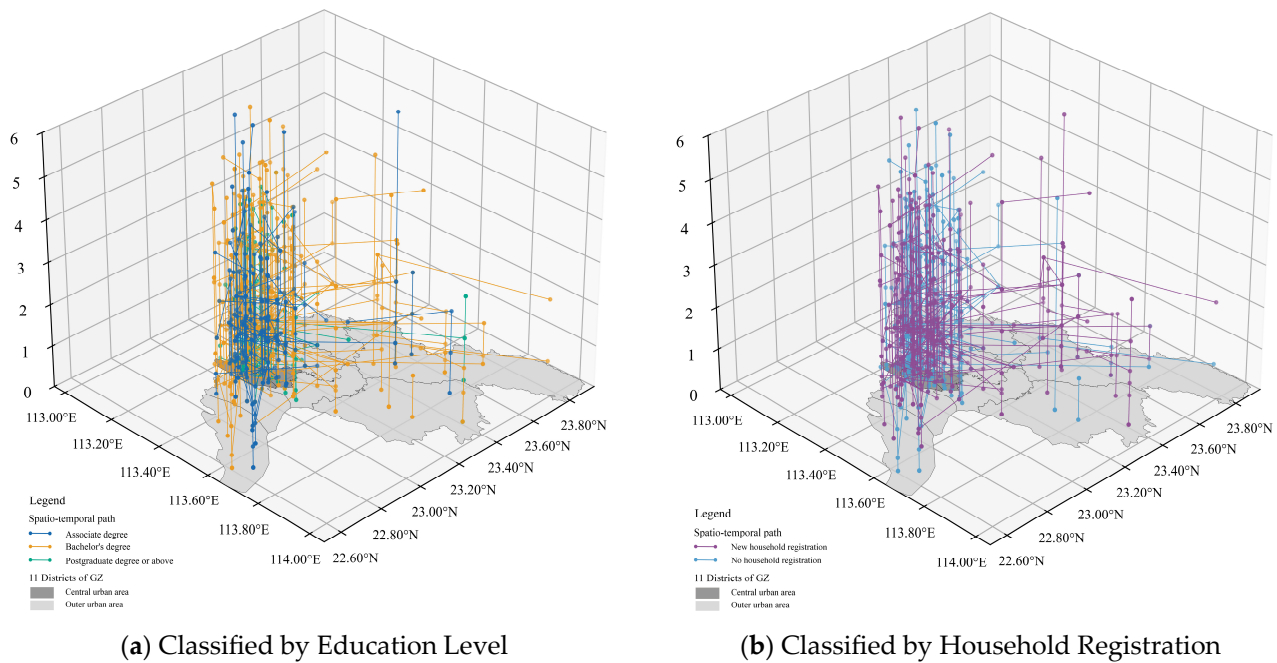


Figure 9. The spatio-temporal path of residential migration among NECGs in Guangzhou.

4.2. Influencing Factors on Residential Mobility of NECGs in Guangzhou

This study employs a multinomial logistic regression model to explore the factors influencing the location choice in the residential mobility of NECGs in Guangzhou. In the VIF test, all independent variables show VIF values below 5, indicating no serious multicollinearity problem. The results of the regression model are shown in Table 3.

Among the variables representing life course attributes, gender and marital status significantly influence the locational change of residential mobility, while age shows no significant effect. The result for gender indicates that female NECGs are more likely than males to move from peripheral areas to central urban areas (-0.147^*). The result for marital status shows that unmarried NECGs are significantly more inclined to reside in peripheral districts compared to those with other marital statuses (17.879^{**}).

Table 3. Results of regression on location choice in residential mobility.

Dependent Variable: Residential Mobility Location Choices (Reference Group: Central-Central)		Central-Peripheral Exp (β)	Peripheral-Central Exp (β)	Peripheral-Peripheral Exp (β)
Independent Variable Type	Independent Variable Name			
Life-course Attributes	Gender (Female)			
	Male	-0.775	0.147^*	0.404
	Marital Status (Other)			
	Unmarried	-0.53	0.457	17.879^{**}
	Married	-1.101	-0.004	16.985
Housing Market Attributes	Age	-0.021	-0.009	0.006
	Housing Ownership Change (Other)			
	Continuous Rental	-0.256	0.181	0.123
	Owner-occupied to Rental	-0.586	1.204	0.462
	Rental to Owner-occupied	-2.215	0.237	0.125
	Continuous Owner-occupied	-0.128	0.202	0.14
	Changes in Housing (Increase)			
	Decrease	-0.502	-1.124^{***}	-1.321
	Remain Largely Unchanged	-0.401^{***}	-1.232	-1.032

Table 3. Cont.

Dependent Variable: Residential Mobility Location Choices (Reference Group: Central-Central)		Central-Peripheral	Peripheral-Central	Peripheral-Peripheral
Independent Variable Type	Independent Variable Name	Exp (β)	Exp (β)	Exp (β)
Accessibility Attributes	Housing Type (Commercial housing)			
	Others	−0.586	0.168	0.366
	Housing Area Change (Increase)			
	Decrease	−0.468	−0.334	−0.353
	Remain Largely Unchanged	−2.289 **	−0.436	−0.591
	Changes in Commercial Facilities (Increase)			
	Decrease	−1.839 ***	0.552	0.042
	Remain Largely Unchanged	−1.188	−1.203	−1.524
	Changes in Educational Resources (Increase)			
	Decrease	0.234 **	1.311	−0.118
	Remain Largely Unchanged	−0.402	−0.985	−1.450 *
	Changes in Medical Facilities (Increase)			
	Decrease	0.493 ***	0.422	0.632
	Remain Largely Unchanged	0.106	0.414	−0.023 *
	Commuting Costs Change (Increase)			
Socioeconomic Attributes	Decrease	0.441	−0.81	0.243
	Remain Largely Unchanged	0.091	0.829	−0.136
	Commuting Distance Change (Increase)			
	Decrease	−0.035	−1.219 *	−0.536
	Remain Largely Unchanged	−0.028	−0.263	0.325
	Household Registration (Non-Guangzhou)			
	Guangzhou	0.329	−0.055	1.183 **
	Educational Level (Postgraduate or higher)			
	Vocational College	−0.981	0.073	0.336
	Undergraduate	−0.587	0.078	0.723
	Disciplinary Categories (Comprehensive)			
	Teacher Education/Finance/Law/Political Science	0.273	−0.509	0.741
	Science/Engineering/Agriculture/Medicine	0.297	−0.502	−0.596
	Ethnic Studies/Language/Arts	1.046	0.724	0.926
	Job Type (Other)			
	Full-time Employment	0.992	0.295	1.236 *
	Flexible Employment	0.226	−0.434	−0.053
	Never Employed	−1.413	−1.579	0.046
	Monthly Income	0.006	−0.06	−0.009
	Duration of Residence in Guangzhou	−0.046	−0.095	−0.045
	Employer Type (Other)			
	Corporate Unit/Company	0.05	−1.948 **	−0.646
	Public Institution	−0.966	−1.74 *	−0.908
	Government Agency	−1.499	−1.2	0.092
	Social Organization	0.671	−2.153	0.339
	Constant Term	1.509	1.731	−19.376 **
		Valid Sample Size: 762		
		Pseudo R ² : 0.674		
		Loglikelihood: 821.25		
		Wald Test (chi2): 185.74		

Note: *, **, *** represent $p < 0.1$, $p < 0.05$, $p < 0.01$, respectively.

Among the variables representing housing attributes, changes in rent, living area, and the level of public service facilities all influence the locational choices in residential mobility among NECGs. The result for rent indicates that NECGs experiencing decreased or stable rent are less likely to move from peripheral districts to central urban areas (−1.124 ***), and those with stable rent are even less likely to move within central urban areas (−0.401 ***).

The result for living area shows that when the area remains stable, the likelihood of moving from middle-class districts to central urban areas decreases significantly (-2.289^{**}). In addition, increasing demand for public service facilities around housing—such as commercial facilities, educational resources, and medical facilities—also contributes to residential mobility.

Among the variables representing accessibility attributes, commuting distance shows a more significant impact. When the commuting distance between the workplace and residence decreases, the likelihood of moving from peripheral districts to central urban areas declines (-1.219^{*}).

Among the variables representing socioeconomic attributes, household registration nature, job type, and employer type closely relate to locational changes in residential mobility. The result for household registration indicates that NECGs with Guangzhou Hukou are more likely to live long-term in peripheral districts (1.183^{**}). Job type and employer type also influence residential mobility. NECGs with full-time jobs tend to remain in peripheral districts (1.236^{*}), while those working in enterprises or companies (-1.948^{**}) and public institutions (-1.74^{*}) are less likely to move from peripheral districts to central urban areas.

Overall, the model results on changes in residential mobility indicate that life course attributes, housing attributes, accessibility attributes, and socioeconomic attributes play significant roles in the residential mobility process of vocational college students. Housing prices, shopping options, medical facilities, marital status, and educational resources are all important factors influencing residential mobility.

5. Discussion

This study focuses on NECGs and investigates their residential mobility behavior from a micro-level perspective, utilizing data from the “Residential Mobility Survey of New Citizens in Guangzhou”. To explore the spatio-temporal pathways and influencing factors of residential mobility among NECGs in Guangzhou, we employ a questionnaire-based method for data collection. The survey sample covers NECGs from various industries and regions across Guangzhou, with questionnaires distributed through multiple channels to maximize sample coverage and enhance the representativeness of the target population. First, this study employs a time-geographic approach to visualize the spatio-temporal paths of residential mobility among NECGs, comprehensively analyzing their relocation trajectories. A multinomial logistic regression model further examines the influencing factors of their residential mobility. The survey sample includes NECGs from various industries and regions in Guangzhou, covering high-density employment sectors such as internet services, finance, and commerce, as well as core employment districts like Tianhe, Yuexiu, and Haizhu. By distributing questionnaires through both online and offline channels, the study ensures broad coverage across different industries and geographic settings, enhancing occupational and spatial diversity in the sample. This approach strengthens the generalizability and representativeness of the findings for the target population. Second, drawing on the existing literature, we recognize residential mobility as an inherently spatio-temporal behavior. Current studies commonly adopt time-geographic methods [56,57]. Following this approach, we utilize the spatio-temporal path visualization method from time geography to comprehensively analyze the residential mobility trajectories of NECGs. This method effectively displays their spatio-temporal relocation patterns. Additionally, we employ a multinomial logistic regression model to examine the influencing factors of NECGs’ residential mobility decisions.

The study of spatio-temporal paths reveals that NECGs exhibit more frequent cross-district residential mobility. Those with higher education levels show lower relocation rates compared to those with lower education levels. Additionally, there are notable differences in cross-district migration patterns between NECGs who have obtained Guangzhou household registration (Hukou) and those without local registration. Currently, empirical research on the residential mobility of NECGs remains limited, with most studies focusing on registered or permanent populations [43]. This study attempts to integrate research on residential mobility and NECGs [58,59], exploring the relocation behavior of this group to provide theoretical and scientific support for improving urban housing policies. In comparison to studies on other cities and populations, existing research on the spatio-temporal characteristics of residential mobility often relies on statistical data to provide basic descriptions of migration patterns at the macro level [60,61]. However, it lacks in-depth analysis of specific subgroups and pays insufficient attention to the differentiated behaviors of individuals with varying educational backgrounds and household registration types. This limitation prevents an accurate understanding of the temporal nodes and spatial trajectories of residential mobility. In response, this study aims to conduct a deeper and more detailed analysis of the residential mobility phenomenon among NECGs in Guangzhou. It categorizes individuals precisely by educational attainment—associate degree, bachelor's degree, and postgraduate or higher—and further divides them into two groups based on household registration natures (Hukou): those newly registered in Guangzhou and those without local registration. By adopting a comprehensive and multidimensional approach, the study seeks to uncover the complex patterns and unique characteristics underlying their residential mobility.

The study on influencing factors reveals that life course attributes, housing attributes, accessibility, and socioeconomic attributes exert varying impacts on residential mobility, with housing prices, shopping options, medical facilities, marital status, and educational resources emerging as significant determinants. Current research on the factors influencing residential mobility predominantly analyzes decision-making processes and their effects on urban spatial structures from demographic or urban geographic perspectives [62,63]. However, there is limited attention to the characteristics of changes in residential location during mobility and their influencing factors. This study integrates residential mobility with changes in residential location before and after relocation, thereby expanding the research on locational changes associated with residential mobility. Furthermore, existing studies on the factors influencing residential mobility among NECGs often focus on single or a few factors, primarily examining life course transitions such as aging [64], changes in marital status, or childbearing [65,66]. Few studies comprehensively consider multiple dimensions, including life course, housing, accessibility, and socioeconomic factors [67,68]. This study constructs a systematic analytical framework that incorporates education level, accessibility, and housing attributes to examine the factors influencing residential location choices during mobility. This approach provides a more comprehensive and nuanced perspective for understanding residential mobility behavior.

Building on existing theories and empirical studies, this study develops a spatio-temporal path model of residential mobility for NECGs and conducts an in-depth analysis of its influencing factors. In doing so, the study provides practical empirical support and a foundational data reference framework for understanding the residential mobility of this population. However, certain limitations and shortcomings remain in this study. First, in terms of data collection, this study primarily relies on retrospective questionnaires to trace the residential mobility history of NECGs over the past decade. While this approach proves somewhat effective, it presents certain limitations compared to longitudinal tracking surveys. A notable issue is survivor bias. The questionnaire sampling struggles to compre-

hensively cover all NECGs, likely excluding graduates who left Guangzhou during this period. The residential mobility patterns and influencing factors of this group remain unexamined, meaning the findings ultimately reflect only the specific population that stayed in Guangzhou, rather than representing the true residential mobility situation of all NECGs. Memory decay also introduces data bias. Due to memory limitations, respondents may struggle to accurately recall details of each residential move over the past ten years, such as exact relocation times or their perceptions of past living environments. Additionally, some respondents may hesitate to disclose complete information for various reasons, further distorting questionnaire data. These issues affect both the accuracy of spatio-temporal path reconstruction and the analysis of influencing factors. To effectively address these challenges, future research should prioritize obtaining updated longitudinal tracking data to more precisely capture the complete residential mobility patterns of NECGs. Furthermore, there is room for improvement in considering the dynamic development of urban areas. For instance, this study lacks timely tracking of NECGs' residential responses to the rise of emerging urban sub-centers and the transformation of peripheral districts. As a result, it is difficult to accurately capture new trends and characteristics of residential mobility under rapid urban changes. Looking ahead, future research should deepen, expand, and refine these aspects to enhance the precision and explanatory power of studies on the residential mobility of NECGs.

6. Conclusions

This study focuses on the residential mobility behavior of NECGs in Guangzhou. Drawing on data from the “Guangzhou New Citizens’ Residential Mobility Survey”, it applies a spatio-temporal path method based on time geography to construct the spatio-temporal paths of residential mobility for this group. Furthermore, the study employs a logistic regression model to analyze the factors influencing residential mobility, taking into account variables such as individual characteristics (life course and socio-economic characteristics), housing features, and accessibility factors.

In terms of spatio-temporal paths, NECGs in Guangzhou exhibit high mobility, with frequent cross-district relocations. They distribute across all eleven districts of Guangzhou without significant clustering or dispersion. Districts such as Panyu, Yuexiu, and sub-districts like Sushe, Xinjiao, and Huangpu show a relatively large proportion of path inflows and outflows. Differences in migration directions exist among NECGs with varying education levels and household registration types. For instance, vocational college graduates and postgraduate groups primarily concentrate in central urban areas before relocating, with most moving to peripheral districts after migration. However, some migration activities still occur within the central districts. In contrast, those with bachelor's degree exhibit more diverse residential mobility patterns, frequently involving transitions between central and peripheral districts as well as relocations within central urban areas. Additionally, there are clear differences in migration patterns between the two groups. For example, migrants without household registration (Hukou) tend to start their migration at younger ages and follow more concentrated directions. Meanwhile, newly settled migrants in Guangzhou show a higher proportion of intra-district or cross-district migration within the central urban areas. Finally, migrants without household registration (Hukou) are more likely to migrate to areas farther from the city center due to higher housing costs and prices, often moving beyond the urban rings.

In terms of influencing factors, the residential mobility of NECGs in Guangzhou is shaped by multiple dimensions, including life course attributes, housing attributes, accessibility attributes, and socioeconomic attributes, each playing a distinct role. Specifically, marital status exerts a significant influence, with unmarried individuals showing a stronger

preference for residing in peripheral urban areas; the effects of gender and age are relatively less pronounced. Regarding housing attributes, housing ownership, changes in housing prices, and living area all play a role. Changes in housing prices, educational resources, and medical facilities are particularly significant. Graduates experiencing a decrease in housing prices, transitioning from renting to owning housing, or maintaining a largely unchanged living area are more likely to relocate from central to peripheral urban areas. Meanwhile, changes in commercial facilities, educational resources, and medical facilities also significantly influence the direction of relocation. Among accessibility attributes, commuting time, costs, and distance collectively affect residential decision-making. In terms of socioeconomic attributes, household registration nature (Hukou), job type, and employer type are closely tied to relocation location. Individuals without Guangzhou household registration (Hukou) tend to prefer peripheral urban areas, as do full-time workers. Graduates employed in enterprises, companies, or public institutions are more likely to move to central urban areas. Additionally, the longer individuals have resided in Guangzhou, the less likely they are to relocate from peripheral to central urban areas.

This study employs the spatio-temporal path approach to thoroughly investigate residential mobility among NECGs, clearly demonstrating the temporal changes in their residential locations. Through quantitative analysis of influencing factors, the research provides micro-level empirical evidence for human geography, breaking through the limitations of macro-level studies and offering in-depth analysis of residential mobility behaviors within this specific population. The findings expand the application of spatio-temporal paths in residential mobility research, establishing a valuable analytical framework for subsequent studies on urban residents' behaviors, space utilization, and residential space formation. Furthermore, the results offer policy references for urban housing strategies aimed at attracting and retaining talent, thereby promoting the optimization of urban talent structures and sustainable socioeconomic development.

This study contributes to a deeper understanding of urban population mobility from a micro-level perspective, thereby providing a foundation for the precise alignment of housing, transportation, and industrial layouts in urban planning. In doing so, it enhances urban spatial efficiency and strengthens the city's ability to attract talent. Looking ahead, future research may incorporate more extensive longitudinal survey data to examine the dynamic changes in urban development and to further explore the driving mechanisms between residential mobility and urban growth.

To promote the settlement and well-being of migrant populations, such as NECGs, and to advance the high-quality development of urban housing in Guangzhou, this study offers the following recommendations:

1. Recommendations for the Housing Demand Side:

Mobile populations should thoroughly understand their housing needs and make informed residential mobility decisions by considering multiple factors. This study demonstrates that the residential mobility decisions of migrants are significantly influenced by life course attributes and socioeconomic attributes. Therefore, when evaluating residential mobility, they need to integrate their financial situation, housing area requirements, and location preferences, while also considering practical factors such as rent affordability, commuting distance, and the level of public service facilities. By selecting the most suitable housing option from a diverse range of choices that align with their individual characteristics, they can avoid poor living experiences or excessive financial burdens, thereby achieving an optimal residential mobility decision.

2. Recommendations for the Housing Supply Side:

As core providers of housing supply, real estate enterprises must accurately understand the structural characteristics of housing consumers. Mobile populations demonstrate significant diversity and variation in residential mobility, with distinct housing feature preferences among consumer groups of different socioeconomic backgrounds and psychological inclinations. Taking education level as an example, associate degree holders may prefer small-sized, low-rent housing near employment centers due to limited financial capacity, while postgraduate groups might prioritize surrounding cultural environments and property service quality, reflecting their higher living standards expectations. Real estate developers should conduct thorough market research and evaluation based on regional characteristics to precisely segment target markets and position their products. Their strategies should not only match housing type and size with different groups' needs—such as compact apartments for young professionals and spacious units for family upgraders—but also address personalized demands for neighborhood amenities and property services. These measures ensure housing products align with local market structural characteristics and fully satisfy diverse consumer needs. In high-demand areas like Panyu District, developers can tailor housing products according to the educational and occupational profiles of local mobile populations. Areas with more associate-degree graduates may require an increased supply of affordable small-sized units, while neighborhoods with concentrated postgraduate professionals would benefit from high-quality, intelligent housing projects with strong academic atmospheres.

3. Recommendations for the Housing Regulation Side:

Governments play a crucial role in housing market regulation and should consistently adhere to the fundamental principle that “housing is for living, not for speculation”, reinforcing its residential nature. In terms of affordable housing supply and rental market development, governments can increase the proportion of affordable housing through policy support and scientific land planning, expanding its scale and optimizing spatial distribution, particularly in areas with high concentrations of mobile populations. Simultaneously, governments should actively guide social capital participation in rental market construction, promoting its diversification and standardization. They need to accelerate the implementation of “equal rights for renters and buyers” policies, refining supporting regulations to ensure renters enjoy equal access to public services like education and healthcare. Regarding property tax legislation and reform, governments should adopt a prudent approach, carefully considering policy stability and effectiveness. They must collect broad stakeholder input, conduct sufficient pilot programs, and perform comprehensive evaluations. Differentiated policies should be developed for various regions and housing demand subgroups. In high-demand areas like Panyu District, governments could implement lower tax rates for first-time homebuyers with genuine needs while applying higher rates to multiple investment properties. This approach would curb speculative behavior, ensure long-term stable and healthy market development, and provide fair, orderly housing environments for all subgroups.

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