Research on occupational relationship and influencing factors in areas along Chengdu Metro Line 1 based on TOD model

Hai Xiao[1*], Yuan Zheng[1,2], Xinyi Xia[2], Liangying Wang[2], Lili Zhang[2]

[1] College of Architecture and Urban-Rural Planning, Sichuan Agricultural University, Dujiang-yan, China
[2] College of Architecture and Urban-Rural Planning, Sichuan Agricultural University, Dujiang-yan, China

* Authors' e-mail: 41228@sicau.edu.cn, 1085457897@qq.com, 2605847231@qq.com, 1329656854@qq.com, 2273386642@qq.com

Abstract. The imbalance between work and housing is one of the obstacles hindering the development of today's cities. TOD is widely regarded as a sustainable urban development model, and it also plays a positive role in adjusting the urban spatial structure. This article takes 800m around the main station of Chengdu Metro Line 1 as the research area, obtains population thermal data through WeChat Yichuan platform, builds a "job-housing relationship model" based on existing research, and uses GIS space such as buffer analysis and nuclear density analysis. The analysis method analyzes the job-housing relationship around the main stations of Metro Line 1. Combined with POI data, the kernel density estimation method is used to explore the factors that affect the relationship between job and residence. The results show that the job-housing ratio in the areas along Chengdu Metro Line 1 is balanced. The areas where the job-housing is greater than the financial city station and the incubator park station are the Guangfu station. The higher the land use mix, the better the job-housing relationship. closer to equilibrium.

Keywords: TOD, Job-housing Relationship, POI, Big Data, Rail Transit

1   Introduction

As an important way of commuting for residents in big cities in my country, rail transit has improved the efficiency of commuting, but to a certain extent has caused an imbalance in the spatial distribution of jobs and housing. As a sustainable urban development model, the TOD model can be adjusted to a certain extent. Phenomenon. At present, the research on the spatial relationship between jobs and housing is mainly in the following two aspects: on the one hand, it is an empirical study on the relationship between jobs and housing. Wang Lucang et al. [1]. On the other hand, there is a study on the factors affecting the separation of work and housing. Qiu Jing et al. used large and small data to analyze the balance of work and housing in the main urban area of Changzhou

and the influencing factors [2]. The research on the relationship between rail transit and job-housing space mostly focuses on the impact of rail transit on the distribution of job-housing space at the macro level [3,4,5] and the matching relationship between rail transit and job-housing space. There are few studies on the spatial relationship between jobs and residences in the surrounding areas of rail transit stations.

Taking the TOD model as the background and taking the area along Chengdu Metro Line 1 as an example, this paper uses population thermal data to explore the job-housing relationship around the main stations of Metro Line 1, and combines POI data to analyze its macro-influencing factors, in order to learn from the TOD model. From the perspective of Chengdu, it puts forward suggestions on the future development of spatial structure in Chengdu.

2 Overview of the study area, data sources and research methods

2.1 Overview of the study are

According to the TOD theory, high-intensity development of land should be carried out within a reasonable walking distance of 400-800m from bus stops, and functions such as commercial, office, residential, plaza, and green space pedestrian systems should be reasonably arranged. Therefore, this study takes the 35 stations along Chengdu Metro Line 1 and the 800m radius of the stations as the research area.

Chengdu Metro Line 1 starts from Weijianian Station in the north, the main line ends at Science City Station, and the branch line ends at Wugensong Station. It realizes the rapid connection between Chengdu's central urban area and Tianfu New District, and plays an important role in boosting the optimization of urban spatial structure and building a networked urban layout structure with "one center, two wings, three axes and multiple centers".

2.2 Data Sources

The data used in this study include: obtaining the population heat of Chengdu at different time periods such as September 24, 2020 (Thursday, working day) at 8:00, 12:00, 18:00, 20:00, etc. Data; obtain POI data on September 25, 2020 (Friday, working day) within the research scope through the Baidu Map API interface, mainly including business residences, companies, transportation facilities services, public facilities services, life services and other categories.

2.3 Research methods

In this study, the kernel density analysis method was mainly used through ArcGIS platform. Firstly, the population thermal data in the study area is analyzed to obtain the spatial relationship between jobs and residences at each site; then representative sites

are selected according to the results, and the surrounding POI data are analyzed to obtain a nuclear density distribution map; Analyze the factors that affect the job-housing balance.

Kernel density estimation is a non-parametric estimation method used to estimate the unknown density function and explore the distribution pattern of points in a certain space. Kernel density analysis of point features is used to calculate the density of point features around each output raster cell. Conceptually, each point is overlaid with a smooth surface with the highest surface value where the point is As the distance increases, the surface value gradually decreases, and the surface value is zero at a distance from the point equal to the search radius.

3   Result analysis

3.1   Population aggregation spatial identification

The population thermal data of different time periods within a radius of 800 meters from the center of Chengdu Metro Line 1 are selected as the basic data. The data collection node selects a normal working day, and avoids weekends or holidays. Thermal data at 12:00 and 18:00 were used to analyze employment activities, and thermal data at 8:00 and 20:00 were used to analyze residential activities. Obtain the thermal points of the corresponding time period through big data and import them into ArcGIS 10.6, and the projected coordinates are WGS_1984_UTM_Zone_48N. The nuclear density analysis of the thermal points was carried out to obtain the nuclear density analysis diagrams of 4 different time periods. The grid calculator was used to obtain the average nuclear density of the employment period and the residential period, and the average result was used as the basis for the identification of the population aggregation space, the pixel size is 100 meters.

3.2   Crowd gathering space during employment time

The average thermal data at 12:00 and 18:00 were selected to explore the spatial distribution of the employment population. The results are shown in Figure 1. From the overall point of view, it mainly shows the characteristics of more centers and less sides, mainly concentrated in three areas from Wenshu Monastery Station to Huaxiba Station, Financial City Station and Tianfu Third Street Station. By comparing Baidu maps, it is concluded that there are many office buildings, shopping malls, medical service institutions, parks, universities, residential areas and other types of buildings in this area. According to the normal laws of urban life, residents have not yet engaged in large-scale shopping, entertainment and other consumption activities, so the population flow is mainly work. The large population heat index at the Tianfu Third Street site is because Tianfu Software Park, which belongs to the national software industry base, accommodates a large number of employed people, thus bringing a peak in the heat value of the employed population.
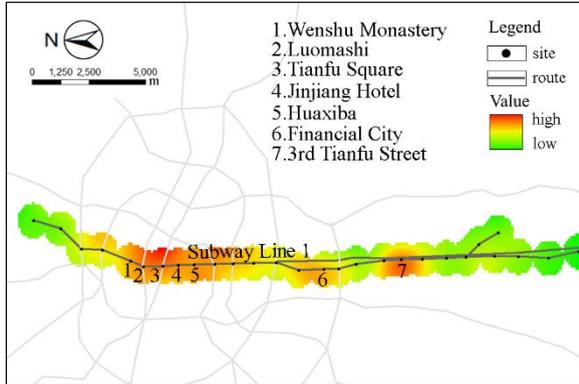
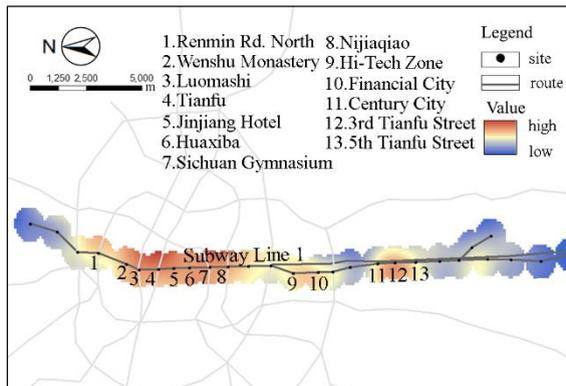**Fig. 1.** Population heat map during working hours

Fig. 2. Population heat map during residence time

3.3   Crowd gathering space during the living period

Select the average value of thermal data at 8:00 in the morning and 20:00 in the evening to analyze the population distribution characteristics of the living time period, as shown in Figure 2. The results show that the crowd is highly concentrated in three areas from Renmin North Road Station to Nijiaqiao Station, Gaoxin Station and Financial City Station, and from Century City to Tianfu Fifth Street. After a Baidu map search, it is found that there are residential areas, vocational colleges, commercial areas, open leisure plazas, transportation hubs, hospitals, office buildings and other types of spaces in the area. It can be seen that the areas with high concentration of people during the living period are mainly residential areas, shopping malls, and square parks.

3.4   Research on the relationship between work and residence space

This study combines the research theories of Cervero and other related scholars, and based on the existing research data, the "job-housing balance index" is used to measure the level of work-housing balance. The job-housing balance index is the ratio of the employment population data to the residential population data within a given range. The formula is as in Equation (1), where Y represents the job-housing ratio relationship within a certain range, Kt1 represents the average thermal value of the heat map during the working time period in this range, and Kt2 represents the average thermal value of the heat map during the living time period in the range.

$$Y = \frac{K_{t1}}{K_{t2}} \qquad\qquad (1)$$

The obtained average thermal data was calculated in ArcGIS to obtain all raster job-housing ratio data in the study area. The results showed that the data were between 0.63 and 1.22, with an average of 1.01. According to the general standard for the index division of the job-housing balance in the current domestic and foreign research, if the ratio is between 0.8 and 1.2, the job-housing balance in the region is considered to be balanced; when the ratio is less than 0.8, it is considered that the job-housing balance is less than the housing, and the region is dominated by living; When the ratio is greater than 1.2, it is considered that employment is greater than housing, and the area is dominated by employment. According to this standard, the obtained job-housing balance results are reclassified, and the study area is divided into three levels: job-less than housing, job-housing balance, and job-housing balance, and the results are shown in Figure 3.
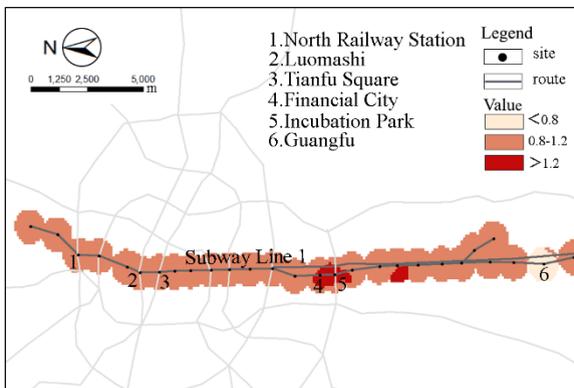

Fig. 3. Job-housing ratio

It can be concluded from the figure that the overall job-housing ratio of Chengdu Metro Line 1 stations is balanced, but there are still uneven areas. The main residence areas of Vocational College are Financial City Station and Incubation Park Station. In this area, there are Tianfu International Financial Center Software Park and Chengdu High-tech Incubation Park, which accommodate a large number of employed people, as well as China Huashang Financial Center and Chengdu Ufang Shopping Center. At the same

time, there are fewer residential buildings in this area, so there is a situation where jobs exceed housing. Guangfu Station has less jobs than housing. The site is surrounded by large residential areas dominated by Blue Cartier and Riverside New World, while there are few office buildings, shopping malls and other commercial office buildings, resulting in the site being a residential-based site. Other sites in the study area are job-housing balance sites, and the proportion of residential buildings and office buildings is balanced.

3.5   Research on the influence of macro-environmental attributes on job-housing relationship

In this study, 6 stations of Line 1 (North Railway Station, Luomashi, Tianfu Square, Financial City, Incubation Park, and Guangfu) were screened out according to the results of the job-housing balance analysis, and quantitative methods were used to analyze the impact of macro-environmental factors on jobs. The impact of housing relationship, using ArcGIS kernel density analysis on real estate community (Figure 4), companies (Figure 5), transportation facilities (Figure 6), public facilities (Figure 7), life services (Figure 8) and other facility services (Figure 8) Figure 9) The nuclear density analysis was carried out, and six types of nuclear density distribution maps were obtained.

Table 1. POI classification table.

|	Main category		Middle class
1	business residence		Industrial parks, residential areas, buildings
2	Corporate		Companies, factories, agriculture, forestry, animal husbandry and fishery bases
3	Transportation Facilities		Airport, railway station, port terminal, bus station, bus station, parking lot, etc.
4	public facility services		Public toilets, newsstands, emergency shelters, etc.
5	Domestic services		Travel agencies, post offices, logistics express, telecommunications business offices, offices, etc.
6	Other service facilities	Medical insurance	General hospitals, specialized hospitals, clinics, medical and health care sales stores, etc.
		Cultural education	Schools, museums, exhibition halls, exhibition centers, cultural centers, libraries, etc.
		Sports and leisure	Sports venues, entertainment venues, holiday recuperation venues, leisure venues, etc.
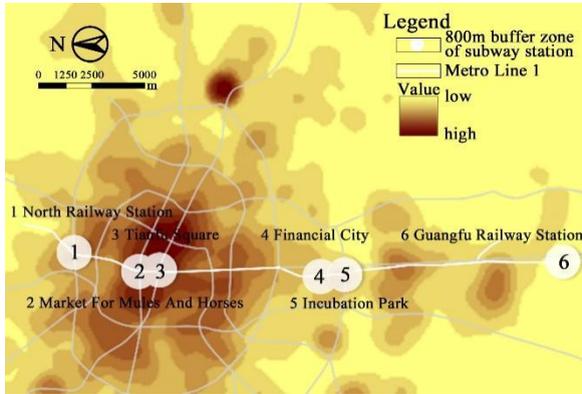
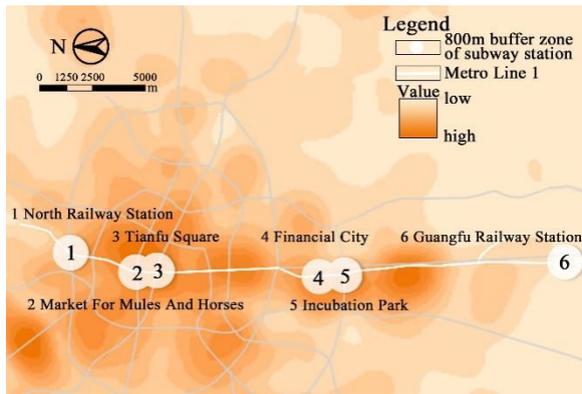**Fig. 4.** Residential Kernel Density Analysis Chart

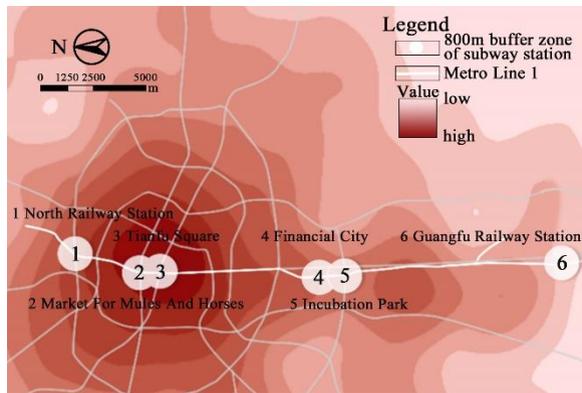**Fig. 5.** Company Enterprise Core Density Analysis Chart

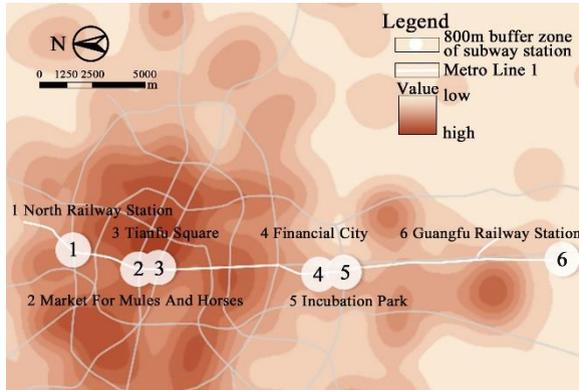**Fig. 6.** Public Utility Service Core Density Analysis Map

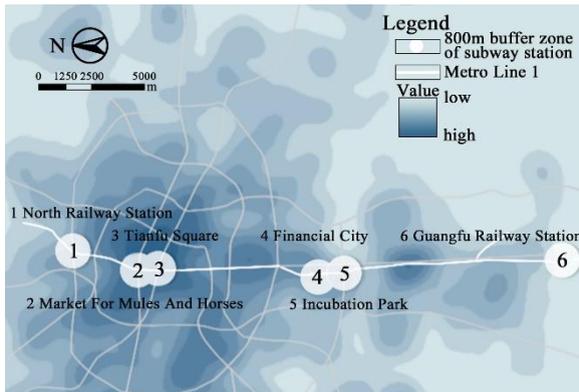**Fig. 7.** Life Service Kernel Density Analysis Chart

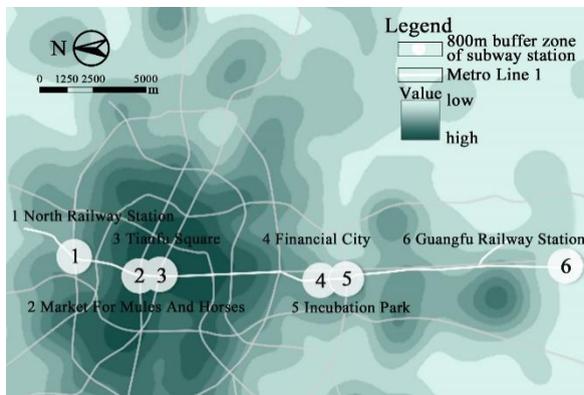**Fig. 8.** Analysis Map of Core Density of Transportation Facilities Service

Fig. 9. Other Service Supporting Nuclear Density Analysis Chart

From the analysis of Figures 4 and 5, it can be seen that the residential and employment densities around the three stations with job-housing balance, namely North Railway Station, Luomashi, and Tianfu Square, are relatively high, and the urban public service facilities and infrastructure construction are all high. It is more perfect, which shows that the higher the degree of land use mixing, the more balanced the job-housing relationship is, which is also consistent with the previous research conclusions.

Take Tianfu Square Station as an example, it is located in Tianfu Square in the center of Chengdu. If Chengdu Metro Line 1 is the main artery in the Chengdu Metro line, then Tianfu Square Metro Station is the heart of Chengdu Metro. Combined with the nuclear density analysis map, the environment outside the station is analyzed: the surrounding business and office areas are dense, and there are Tianfu Center CBD (Central Business District), Territory Center, City Heart and Baiyang Building and other large business office areas. In addition, many landmark buildings such as Sichuan Provincial Library and Grand Theater have been built around the station. There are nearly 10 Tianfuhong Shopping Center, Renhe Spring Department Store, Maoye Tiandi, etc. 500 meters away from the station. shopping mall. The agglomeration of these functions can reduce transportation costs for people's work and life, and broaden the living radius.

4   Conclusion and suggestion

Based on the above research results, the following conclusions and recommendations are drawn:

(1) Improve employment and living environment

The Financial City Station and the Incubation Park Station are located near Tianfu New District, which are attractive for employment, but their supporting living spaces are relatively small and the housing prices are relatively high. Many workers cannot afford the high housing prices and choose long-distance commuting. For such areas, it is first necessary to improve the living environment, improve the housing rental market and optimize the supply structure of commercial housing, build a reasonable housing supply system, allow more employees to live nearby, and optimize related supporting facilities; In the residential area, more jobs are created by strengthening economic and industrial development, ensuring the diversification of job types, so as to meet the needs of different types of workers.

(2) Building a comprehensive transportation network

Chengdu should fully combine the existing rail transit lines to mix the city's employment, residential, commercial and other functional areas, pay attention to the combination of transportation mode and land use mode, carry out TOD mode development, rely on stations and along the line to mix functional areas, effectively Promote the development of spatial agglomeration in Chengdu.

References

1. Wang Lucang, Chang Fei. (2020) Research on the spatial relationship between jobs and residences in the main urban area of Lanzhou City based on multi-source data. Human Geography., 35(03):65-7.
2. Qiu Jing, Qin Xiao, Zhen Feng. (2020) Research on the influencing factors of urban job-housing balance based on the combination of large and small data:taking the main urban area of Changzhou as an example. Modern Urban Research., 06:56-63.
3. Ru Xianghui, Yang Zhigang, Zheng Meng, Yao Zhisheng. (2022) Strategies for the coordinated development of rail transit and space in megacities—taking Beijing as an example. Urban Transportation., 20(02): 21-27+110.
4. Zhang Yan, Cui Zhixiang, Zhu Xiaobing, Gu Zhihui. (2021) The evolution of urban job-housing space in Shenzhen under the influence of rail transit. Residential District., 05:104-120.
5. Chen Tao. (2021) Changes in Shanghai's work-housing balance under the influence of rail transit. Shanxi Architecture., 47(06): 1-4+8.