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# Classification of Beijing Line 10 Subway Living Circle Based on Multi-source Big Data

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**Abstract** In the first-tier cities, subway has become an important carrier and life focus of people's daily travel activities. By studying the distribution of POIs of public service facilities around Metro Line 10, using GIS to quantitatively analyze the surrounding formats of subway stations, discussing the functional attributes of subway stations, and discussing the distribution of urban functions from a new perspective, this paper provided guidance and advice for the construction of service facilities.

**Keywords** Multi-source big data, Subway living circle, Beijing, GIS
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## 1 Data sources and research scope

### 1.1 Data sources

POI (point of interset, point of interest) data mainly refers to some geographic entities closely related to people's lives[1]. The POI data set carries the spatial information and attribute information data of these entities, which can quickly and intuitively obtain the distribution of such functions in the city, and can also more intuitively reflect the accumulation characteristics of urban functions[2].

The POI data used in this article was obtained from the AutoNavi map in 2021, with a total of 360,743 valid data. The data has been cleaned, filtered and reclassified, and a total of 82,162 were retained. The types of points of interest were divided into 4 categories: A company, B residential area, C municipal facilities and D leisure and entertainment.

### 1.2 Scope of the study

The research object of this paper is Beijing Metro Line 10, which is a circular line and has the largest passenger flow among the Beijing subway lines. It passes through Fengtai District, Haidian District, and Chaoyang District, with a total of 45 stations[3]. This paper used GIS to cut the site space with Thiessen polygons, and then intersected the acquired POI data with it to obtain the proportion of different types of POI in the Thiessen polygons of each site (Fig.1).

## 2 Data processing

### 2.1 POI reclassification

From the AutoNavi map interface, POIs of the surrounding 45 stations of Line 10 were obtained, mainly including catering, leisure, shopping, accommodation, parks, corporate offices, finance, etc.[4]. It was divided into 4 categories: company type, residential area type, municipal faclility type and leisure and entertainment type. The specific classification is shown in Table 1.

### 2.2 Factor correlation test

As can be seen from Table 2, correlation analysis was used to study the correlation between companies, residential areas, municipal facilities, leisure and entertainment and the proportion of company enterprises, residential areas, municipal facilities, and leisure and entertainment. Use the Pearson correlation coefficient to express the strength of the correlation. The specific analysis shows that:

The correlation coefficient between the proportion of the company and the residential area is −0.431, and it is significant at the 0.01 level, thus indicating that there is a significant negative correlation between the company and the proportion of the residential area. The correlation coefficient between leisure and entertainment and the proportion of residential areas is −0.491, and it is significant at the 0.01 level, thus indicating that there is a significant negative correlation between leisure and entertainment and the proportion of residential areas. The correlation coefficient between the proportion of leisure and entertainment and municipal facilities is −0.425, and it shows a significant level of 0.01, which indicates that there is a significant negative correlation between the proportion of leisure and entertainment and municipal facilities.

This means that in the process of urban planning in Beijing, commercial land is not closely related to residential land, and as the capital, administrative office land is not closely related to entertainment facilities.

In addition, the correlation between the proportion of corporate enterprises and municipal facilities and the proportion of leisure and entertainment does not show significant correlation ($p > 0.05$), which means that the proportion of corporate enterprises and municipal facilities, leisure and entertainment There is no correlation between the two items in the proportion of entertainment. The value of the correlation between leisure and entertainment and the proportion of companies and enterprises does not show significant value ($p > 0.05$), which means that there is no correlation between leisure and entertainment and the proportion of companies and enterprises.

### 2.3 Urban functional density distribution of each station of Line 10

By intersecting the Thiessen polygon of Beijing Metro Line 10 with the crawled POI, the interest points in the Thiessen polygon are retained, and the kernel density analysis is performed on the retained POI interest points, as shown in Fig.2. Through the comparison of experimental data, the POI value of the residential area is enlarged ten times, and the POI value of municipal facilities is doubled to correct the error[5].

As shown in Fig.2a (company), the companies on Line 10 are mainly concentrated in the east section, Sanyuanqiao, Tuanjiehu, and Guomao Station. The Suzhou Street Station in the northern section is more concentrated, mainly because this station is located near Haidian District Science and Technology Industrial Park.

Fig.2b shows that the residential areas along Line 10 are widely distributed, and the eastern

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**Table 1 POI reclassification indicators**

| Primary classification | Secondary classification | Three-level classification |
|---|---|---|
| A Company | a1 Technology manufacturing | Science and technology parks, industrial parks, office buildings, etc. |
| | a2 Finance | Banking, insurance, securities, etc. |
| | a3 Life service | Housekeeping, wedding services, water and electricity services, furniture city, car sales, car beauty, etc. |
| B Residential area | b Residential area | Apartments, communities, nursing Homes, dorms, etc. |
| C Municipal facilities | c1 Government department | Public security agencies, state-owned enterprises, radio and television stations, representatives of government agencies, community services, etc. |
| | c2 Foreign affairs department | Embassies, consulates, military, etc. |
| | c3 Others | Charging piles, service area toll stations, newsstands, express logistics sites, gas stations, orphanages, welfare homes, nursing homes, etc. |
| D Leisure and entertainment | d1 Restaurant hotel | Chinese food, Western food, local specialty food, cafes, restaurants, bars, etc. |
| | d2 Shopping | Beauty salons, clothing accessories, gyms, health clubs, supermarkets, etc. |
| | d3 Park green space | Farmhouses, museums, exhibition halls, libraries, parks, squares, green spaces, etc. |

**Table 2 Factor correlation test**

| | Company | Residential area | Municipal facilities | Leisure and entertainment |
|---|---|---|---|---|
| The proportion of the company | 0.584** | −0.175 | 0.111 | −0.031 |
| Residential area | −0.431** | 0.342* | −0.027 | −0.491** |
| The proportion of municipal facilities | −0.256 | 0.107 | 0.423** | −0.425** |
| The proportion of leisure and entertainment | 0.133 | −0.236 | −0.263 | 0.664** |

*Note*: * $p < 0.05$ ** $p < 0.01$.

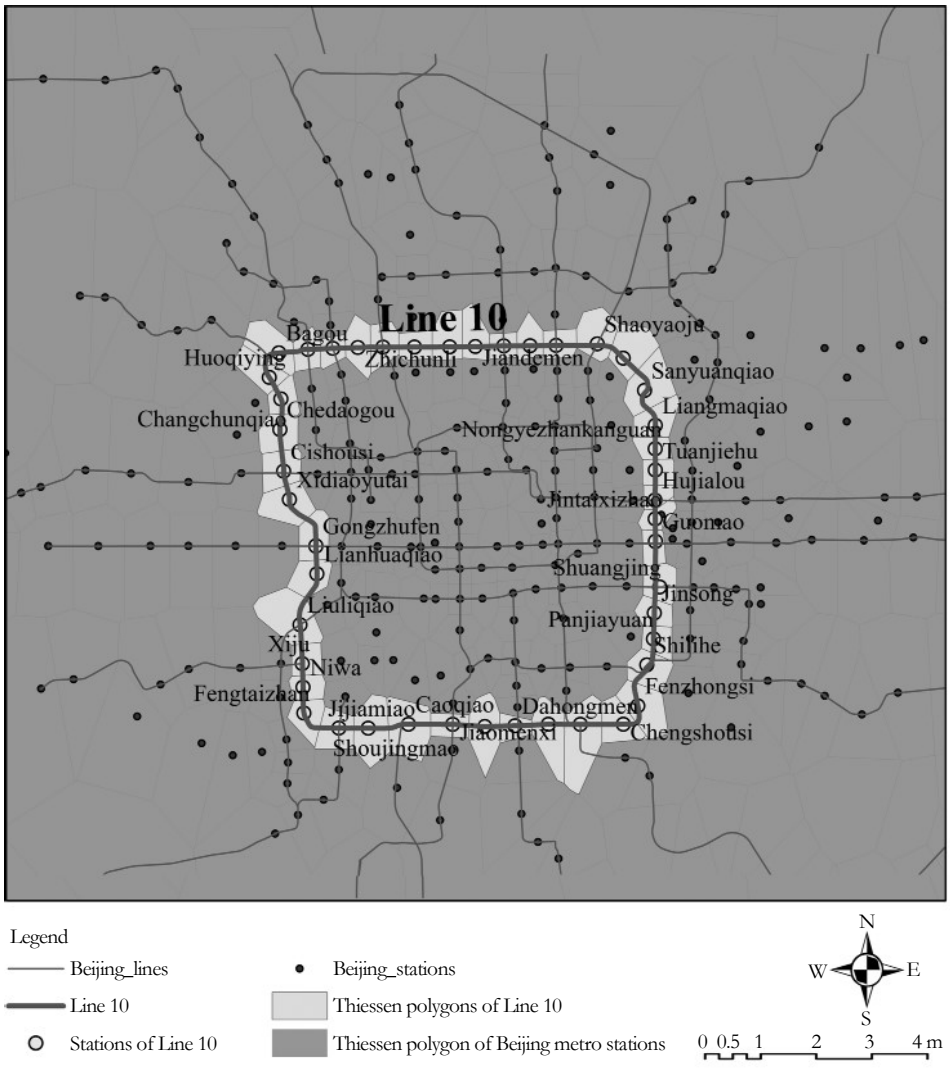


**Fig.1 Schematic diagram of the Thiessen polygon of Line 10**

section mainly includes Tuanjiehu, Shuangjing, Jinsong, the clusters of Panjiayuan and Shilihe are more obvious, Peony Garden and Zhichunli Station in the north are more obvious, and Cishou Temple in the western section and Songjiazhuang and Jiaomendong in the southern section also have a relatively significant clustering trend. The distribution of residential areas is generally denser in the northern and eastern sections, mainly due to the fact that there are relatively concentrated residential areas around the Panjiayuan Shuangjing Station in the eastern section, and there are also a large number of residential areas in Peony Garden in the northern section. The overall kernel density shows that the planning of the residential area is more inclined to the eastern and northern sections, that is, it is concentrated between the North Third Ring Road and the North Fourth Ring Road in Beijing and on the East Third Ring Road.

As can be seen from Fig.2c, municipal facilities are mainly concentrated in the northern and eastern sections. The northern section is offset from Suzhou Street to Peony Garden. Near Suzhou Street, there are Beijing Haidian District Education Science Research Institute and Beijing Municipal Administration of Market Supervision and other units, and Haidian Huangzhuang Station has higher education institutions of the Ministry of Education. Social Science Development Research Center, etc.. The eastern section is mainly concentrated in Liangma Bridge, Agricultural Exhibition Hall, Tuanjie Lake, and Hujialou Station. Near the Agricultural Exhibition Hall and Tuanjiehu Station, there is Dongzhimenwai Street, which is the concentrated area of embassies.

Fig.2d shows that leisure and entertainment is mainly located in Tuanjie Lake, Guomao, Shuangjing and Shili River in the eastern section, and Changchun Bridge in the western section. Guomao is located in the core

area of Beijing CBD. Nearby there are Jianwai SOHO, CBD Forest Park, Beijing Guomao Hotel, Tuanjie Lake and Hujialou. There are Tuanjie Lake Park, Sanlitun Business Circle, Worker's Stadium, etc. near the site, R&F City Business Circle near Shuangjing, and Shilihe Cultural Park, Shilihe Jewelry, Capital Library and other facilities.

### 2.4 Functional classification of each station of Line 10

By classifying different POI types of each subway station, 45 subway stations of Line 10 are finally classified into single-factor type, double-factor type and multi-factor type subway stations. The classification statistics are shown in Table 3.

As shown in Fig.3a and Fig.3b, for the single-factor stations on Line 10, there are Cishou Temple Station dominated by residential areas, and Shilihe, Changchun Bridge, Gongzhufen and Bagou as leisure and entertainment types. Combining the kernel density analysis chart, it can be seen that Cishou Temple site is not the most densely populated area of residential

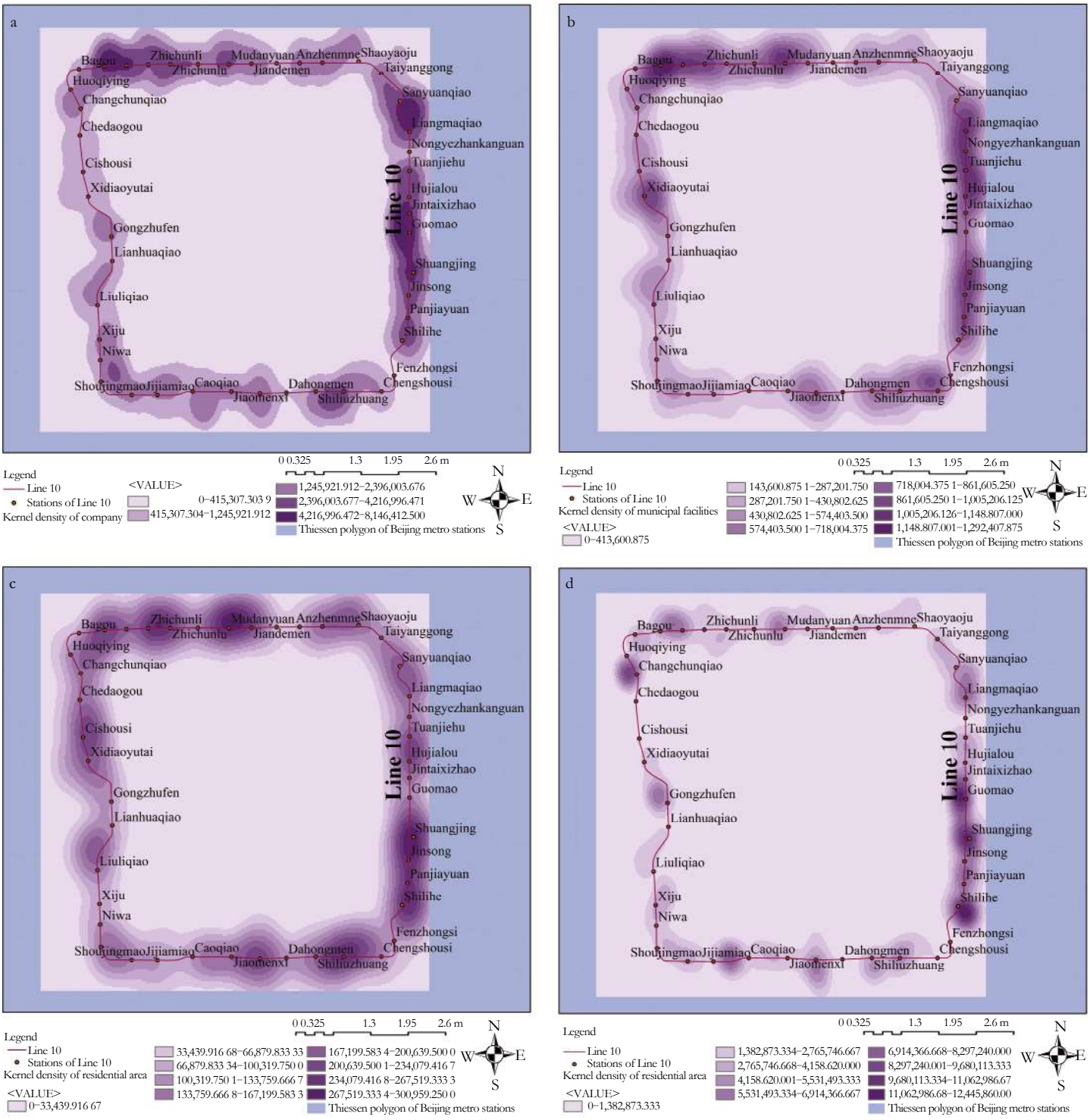


**Fig.2 Kernel density of company (a), residential area (b), municipal facilities (c), leisure and entertainment (d)**

areas, but from the POI ratio, it can be seen that the residential area of this site occupies a dominant position in the area; Shili River and Changchun Bridge are on Line 10. The kernel density map of leisure and entertainment POIs is also significant. Gongzhufen and Bagou are located in Haidian District, but not so significant in the kernel density map of Line 10 leisure and entertainment POIs. Yuyuantan Park dominates the POI classification at Gongzhufen site, and there are nearby POIs. Urban and rural shopping centers and Cuiwei Plaza and other business districts, Bagou Station has Wanliu Golf Club and Beijing Hualian Wanliu Shopping Center, which makes the site a type of leisure and entertainment-oriented site.

From Fig.4a, it can be seen that there are 5 AD-type stations in the two-factor type on Line 10. Tuanjiehu, Guomao, Liangmaqiao and Jintaixizhao stations are located in the East Third Ring Road, CBD Historical and Cultural Park, Beijing CBD Core Area, Sanlitun Commercial The circle is scattered among them. Haidian Huangzhuang is located in Haidian District, and there are core functional spaces such as Zhongguancun Building and Haidian Theater nearby.

Fig.4b shows that there are a total of 7 BD-type stations, mainly in the southern section of Line 10, between the South Third Ring Road and South Fourth Ring Road, in Fengtai District, while Panjiayuan Station and Shuangjing Station are located on Line 10 The eastern section of the line is located on the East Third Ring Road in Chaoyang District. There are Panjiayuan Antique Market, Qingfeng Park, and R&F City Business District nearby.

From Fig.5a and Fig.5b, it can be seen that there are 9 ABD-type stations and 19 ABCD-type stations. The multi-factor type subway stations are mostly distributed in the western and northern sections of Line 10, between the West Third Ring Road and the West Fourth Ring Road. The location of Haidian District, the northern section is located in Chaoyang District, between the North Third Ring Road and North Fourth Ring Road, the distribution of multi-factor sites in POI is relatively uniform, and there is no absolutely dominant functional type. The distribution of interest points is different due to the difference of space.

### 2.5 Analysis of functional components of stations at different spatial locations on Line 10

By dividing the ring-shaped subway station into four different directions: east, west, south and north, the northern section is located between the North Third Ring Road and the North Fourth Ring Road, located in Chaoyang District, and the southern section is located between the South Third Ring Road and the South Fourth Ring Road. Between the rings, it is located in Fengtai District, the east section is located on the East Third Ring Road, located in Chaoyang District, and the west section is located between the West Fourth Ring Road and the West Third Ring Road, located in Haidian District.

Fig.6a shows the proportion of different POIs in the northern section of Line 10. There are 11 stations in the northern section, passing through Zhongguancun business district, Beichen business district and Wangjing business district. You can see the leisure activities of Beitucheng and Bagou stations. The proportion of entertainment is relatively high. There is Wanliu Golf near Bagou Station, the functional space of the residential area in Peony Garden is relatively high, and the company function space and leisure and entertainment function space of Haidian Huangzhuang Station are relatively high. The main reason for the fluctuation in the proportion of POI functions in subway stations.

Fig.6b shows the proportion of different POIs in the eastern section of Line 10. There are 13 stations in the eastern section, passing through Yansha business district and Guomao business district, located in the core business district of Beijing. Comparing the northern section, it can be seen that the fluctuation situation is relatively high. Obviously, the proportion of residential areas is not high, and the proportion of corporate enterprises and leisure and entertainment types is higher. The leisure and entertainment function space of Shilihe is relatively high, the leisure and entertainment function space of Tuanjie Lake and Guomao Station and the corporate function space are relatively high, the residential area of Shuangjing and Shaoyaoju Station is relatively high, and the municipal agricultural exhibition hall has a relatively high proportion of functional space. The facility function space accounts for a relatively high proportion, and at the same time, the corporate function space for the site accounts for a relatively low proportion.

Fig.6c shows the proportion of POIs at each station in the western section of Line 10. Changchun Bridge, Gongzhufen and Xiju Station have a relatively high proportion of leisure and entertainment space. There is Yuyuantan Park near Gongzhufen, and Xiju Station and Niwa Station are nearby. Beijing Fengtai Lize Financial Business District, and the residential areas of Cishou Temple, Lianhua Bridge, and Fengtai Station account for a high proportion of functional space, which are the main reasons for the fluctuation.

There are a total of 10 subway stations in the southern section, as shown in Fig.6d. The southern section is close to Lize business district, and Dahongmen is located on the southern central axis, reducing the functional space for companies and municipal facilities.

**Table 3 Classification of Line 10 stations**

| Category | One-factor | Two-factor | Multi-factor |
|---|---|---|---|
| Number of subway stations | 5 | 12 | 28 |
| North Section | 1 | 1 | 9 |
| East Section | 1 | 6 | 3 |
| West Section | 3 | 1 | 7 |
| southern section | 0 | 4 | 6 |

## 3 Conclusion and analysis

### 3.1 Research conclusions

Based on the above analysis, the following conclusions can be drawn:

This study uses GIS analysis and SPSS correlation analysis and other methods to analyze and demonstrate the proportion and distribution characteristics of each point of interest (POI) in 45 stations of Line 10. Functional properties of subway stations. On the whole, Line 10 runs through almost all the mature 8 prosperous business districts in Beijing, with multi-factor sites occupying the majority.

From the analysis results: ① the urban function of the subway station is correlated with its urban spatial location; ② the urban function around the subway station is closely related to the urban interface. Judging from the overall quantity distribution of POI data and the proportion of POI data of various types, sites such as Guomao, Tuanjiehu, Sanyuanqiao, Suzhou Bridge and other sites are represented, and there are many companies and enterprises. Peony Garden, Songjiazhuang, Shilihe and other sites are dominated by residential areas. Sites such as Firearms Camp, West Diaoyutai, and Sanyuan Bridge gather a large number of municipal facilities. Sites such as Shilihe, Guomao, Changchun Bridge, and Caoqiao are typical sites for leisure and entertainment. The

POI distribution and characteristics of each typical site are also different.

The study found that the urban functional attributes of subway stations are closely related to the urban spatial location of the stations. Taking Guomao and Tuanjie Lake as examples, because Guomao is located in the CBD and is a commercial center, the company and leisure and entertainment POIs dominate; around Tuanjie Lake are the Sanlitun business district and the Workers' Stadium business district. Sanlitun is a typical open type in Beijing. The commercial pedestrian street, the Workers' Stadium and the surrounding business circles form POI functional spaces for corporate enterprises and leisure and entertainment, and become important urban functional nodes.

In the future development and construction of urban rail in Beijing, it is necessary to optimize the functional layout and structure of relevant stations based on the urban interface and urban functional positioning, and to plan based on the advantages and disadvantages of the geographical space of the stations, and to balance the functional attributes and roles of each station, efficiently develop and utilize site space. Combined with urban planning, the layout of the stations is more optimized and reasonable, the potential of urban development is fully tapped, the stations with unreasonable resource allocation are adjusted in a timely manner, the vitality and power of the functional layout of the stations are improved, and suggestions for the future development of urban rail space are provided.

### 3.2 Insufficient research

Due to limited conditions, there are still many shortcomings in this study to be improved in future research.

The POI data obtained from the Internet map open platform has undergone a lot of cleaning and correction processing. To make the data closer to the real value, some POIs were expanded tenfold and doubled, which has no critical impact on the research conclusions, but

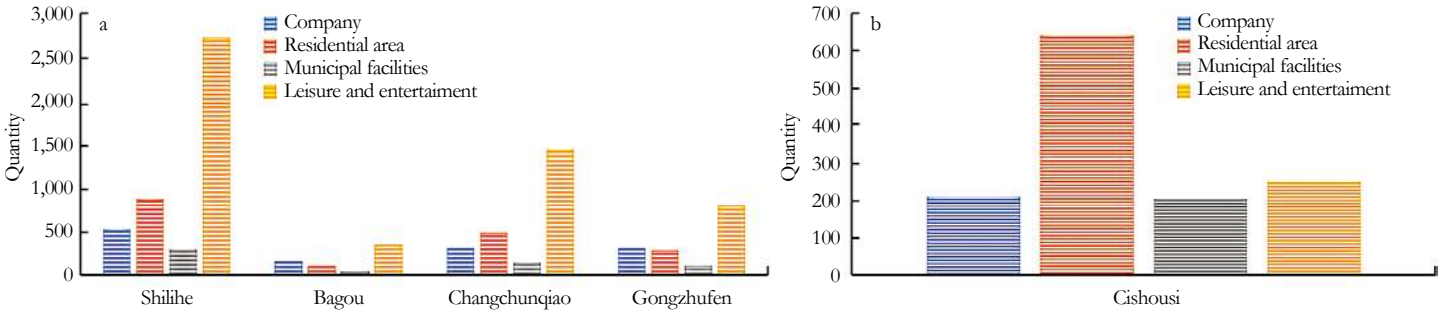


**Fig.3 D–type (a) and B–type site (b)**

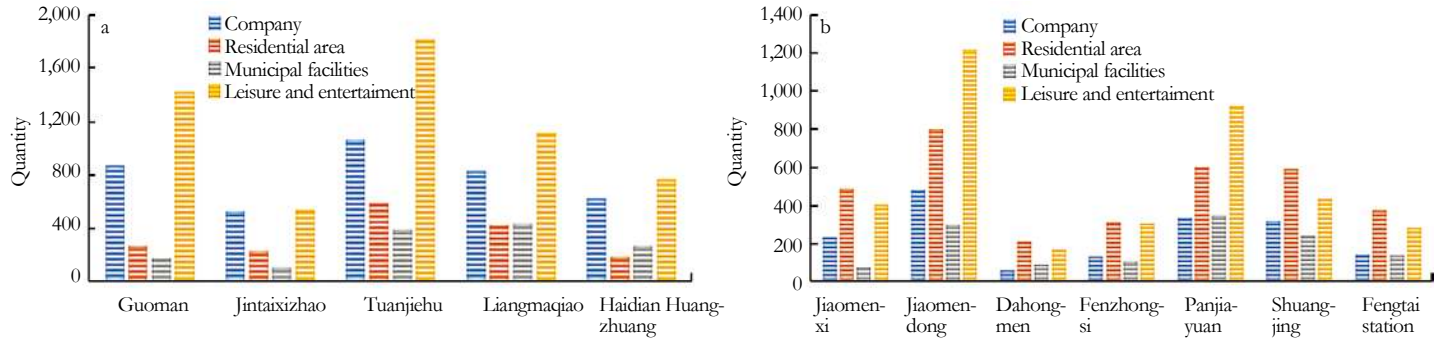


**Fig.4 AD–type (a) and BD–type (b) subway station**

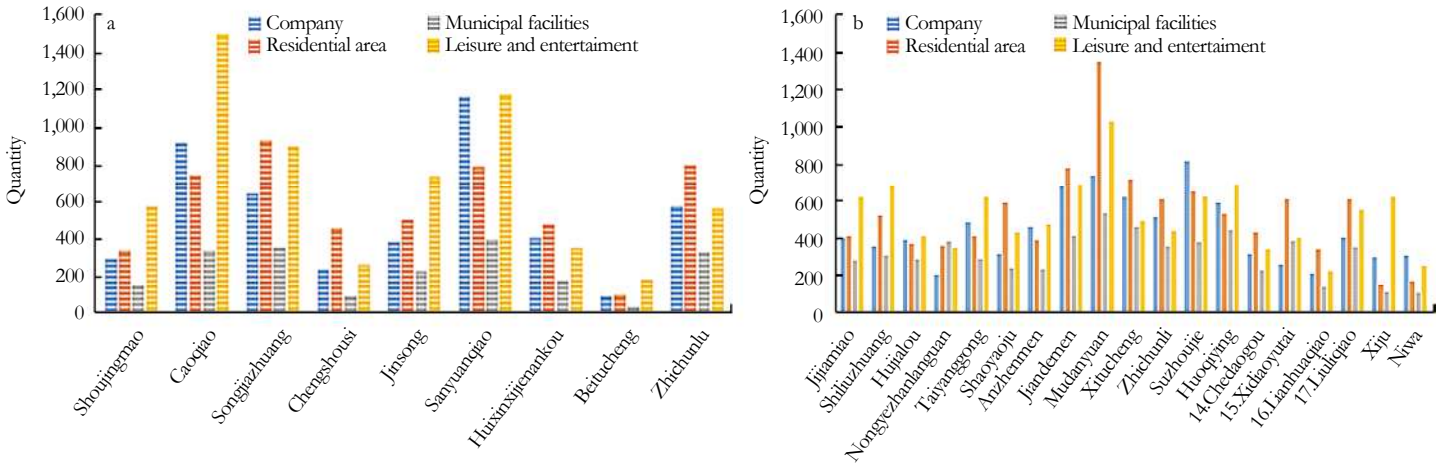


**Fig.5 ABD–type (a) and ABCD–type (b) subway station**

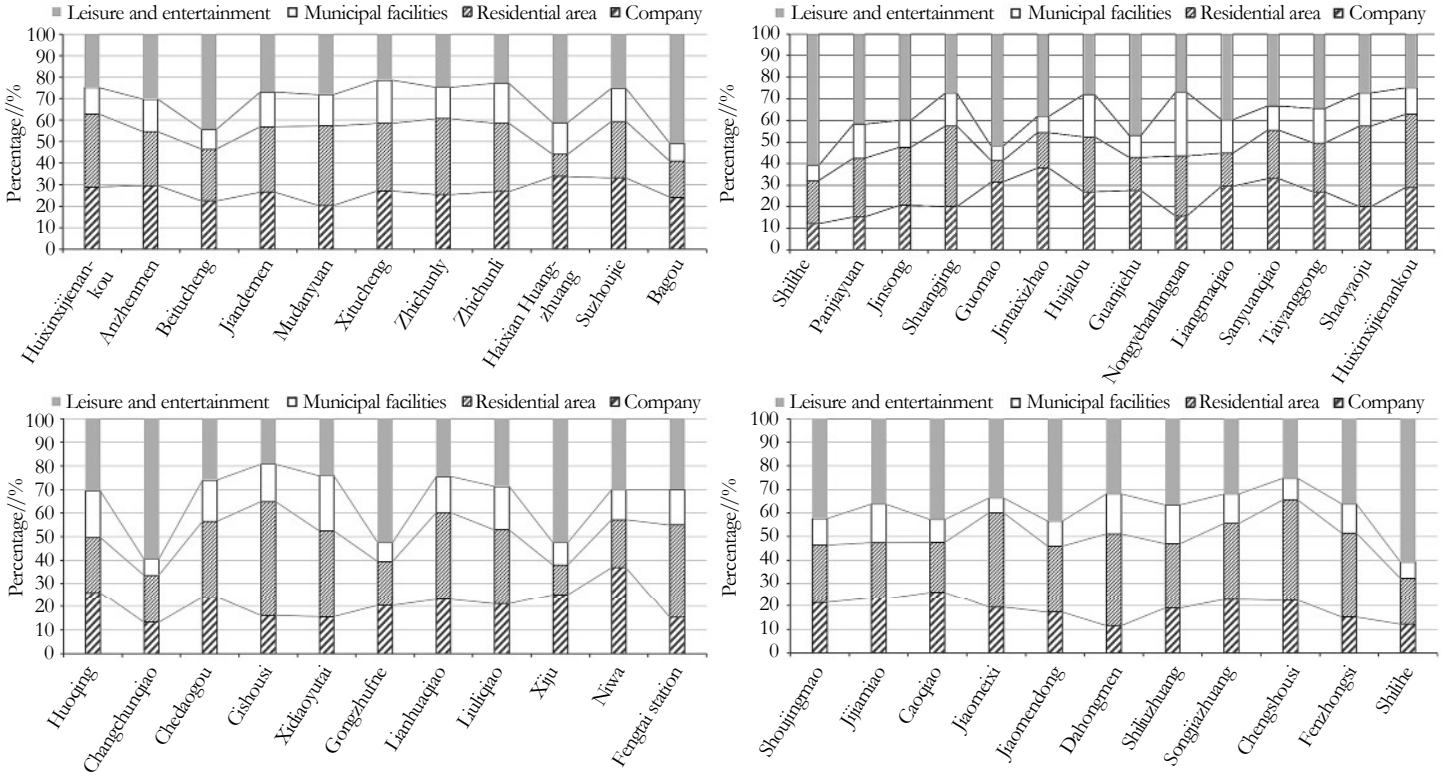


**Fig.6 Analysis of POI proportion of northern (a), eastern (b), western (c) and southern (d) subway stations**

still need to be corrected and supplemented by field investigation.

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