ID 1393 | WHERE IS THE COMMUTERS? RESEARCH OF SHANGHAI COMMUTING TRAFFIC BASED ON TRANSPORTATION CARDS DATA

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1 INTRODUCTION

With the rapid urbanization, revolution of housing policy and the development of public transportation technology, the high price of city center drives people to move to the suburbs, the distance between home and workplace shows a sharp rising. Daily commuting becomes an important part of daily life and a crucial issue that cities need to face. On this occasion, commute is becoming a universal phenomenon and a prevalent research issue.

Without exception, commute is becoming a widely common phenomenon in Shanghai which is located in the Yangtze River Delta metropolitan area. In Shanghai, most of commuters select metro as the tool of commuting because of the relevant reliability and punctuality. As shown in the figure 1, hundreds and thousands of commuters crowd onto the metro during the morning and evening rush hours every day in Shanghai. Such curiosity gives rise to this commuting behaviors, emphasizing on spatial distribution of the places that commuters live and work, the commuting transportation tool (diversification or simplification) they choose, some potential suggestions and advice for the decision-making and policy-setting produced based on the commuters' behaviors, with appropriate quantitative evidence and visualization illustrations.

Figure 1 – The metro commuters in Shanghai (Source from: Liu Xiaochang, 2017)

The commuters' behaviors play an important role in studying the structure of jobs-housing spaces. Robert Cervero (1996) proposed that the imbalance between home and workplace contributed to the commuting behaviors [1]. Levinson proposed the accessibility to substitute the balance between employment and residence to analyze the impact of urban commenting. He found that higher accessibility contributed to the less time consumption for commuters. Therefore, Levinson concluded accessibility was more convincing to analyze the commuting behaviors. [2] The commuting behaviors were impacted by the urban spatial structure, major researches focus on the scale of city, the density of residence and employment, as well as mixed land use. Cuertis' research indicated that high-density and inclusive development was beneficial to public transportation. [3] Besides, social elements were also regarded as the important aspects to analyze the commuting traffic. Based on Hanson' research, some social and economic indicators such as age, gender and income can be applied to analyze the commuting behaviors. [4] For many western countries, the official data like the data of population census are open, specific, easy and free to obtain, even some data in individual level are also public, which provide the data base to analyze the groups of commuters and even the individual commuter. Therefore, western researches of commuting traffic are more quantitative and precise.

However, Chinese researches of commuting behaviors are mainly based on fieldworks and social observations. Yanwei Chai (2002) applied the theory of time-geography, and found that the features of time, space, travelling and the methods of travelling were the main elements impacting the commuting traffic. [5] Ke Wang (2010), Yaping Wei (2012), Lin Qiu (2007) found that the percentage of commuters who directly choose the metro as commuting tool would gradually decrease, if the distance from work place or home to metro station increased. Comparatively, the percentage of commuters who took bus firstly and transferred subway would obviously raise. [6] [7] [8] Owing to the limitation of official data about

the relationship between working space and residence place for inhabitants, majority of data are from the survey observation, and sample quantification is significant small. Therefore, a lot of researches only focus on the descriptive analysis of individual commuting behaviors, rather than some particular groups' behaviors.

Compared with traditional, sampling, partly-quantitative and qualitative analysis methods, the approaching Big Data era provides totally systematic and quantitative methods. Traffic and passengers flow can be precisely described and analyzed based on the whole sample statistic and database. From the macroscopic perspective, the structure of jobs-housing space in Shanghai can be described precisely and analyzed quantitatively in this research. Meanwhile, characteristic rules of special commuters' behaviors from the microscopic perspective. Furthermore, some specific and precise suggestions and advice can be provided for the decision-making and policy-setting of transportation.

2 DATA MINING AND ANALYSIS METHODS

2.1 DATA MINING

The database is based on the metro transportation card data of five continuous weekdays from 30th March, 2015 to 3rd April, 2015. Specifically, database includes the average 9.1 million pieces of data per day from 288 metro stations of Shanghai. There are five important attributes of any certain piece of data: the card number, the name of start metro station where one certain commuter starts his/her commuting travelling, the name of the end metro station where one certain commuter finishes his/her commuting travelling, the time of entering the start metro station for one certain commuter, the time of leaving the end metro station for one certain commuter and the duration from start metro station to end metro station, which are presented in the table 1.

Card number	Name (Start)	Name (End)	Time (Start)	Time (End)	Duration
79796	Road Yan'an	Road Guilin	7:52:05	8:36:42	44
84407	Road Songyuan	Road Siping	9:40:09	10:08:06	28
92416	Beixinjing	Lujiazui	7:44:46	8:14:38	30
.....	.....	.....	.....	.....	.....

Table 1 – The main attributes of metro transportation cards data (Source from: Liu Xiaochang, 2017)

2.2 DATA CLEANING

The subject of research is commuter, therefore data cleaning is necessary. There are three principles of data cleaning. First of all, commuters have nearly same commuting travelling modes every day. If one certain card number only appears once or twice in the database during the five continuous weekdays, the owner of the certain card will not be studied as a commuter in this research. Therefore, this research only focuses on those card numbers that continuously appear three and more than three times. Secondly, this research only focuses on the time of leaving the end metro station is before noon (12:00). In other words, the owner of the certain card who leaves the end metro station after noon will not be regarded as commuter, because the nearly all companies in Shanghai are open before 12:00. Last but not least, the duration of commuting is less than 2 hours (120 minutes). If one certain data simultaneously satisfies the three principals, the data will be defined as the effective one of the database.

2.3 ANALYSIS METHODS

The time of entering and leaving the metro station is random. If this research adopts the method of classification on separated time points, the quantity of data will become significantly huge and the classification will become more difficult. Therefore, classification on comparatively longer period of time is adopted as the analysis method. Precisely, this research defines 30 minutes as one unit period and divides the running time of metro (from 5:00 to 23:00) into 38 periods. In every period, frequencies of entering and leaving metro stations will be accumulatively and independently counted as shown in the table 2 and table 3.

	5:00 - 5:30	5:30 - 6:00	6:00 - 6:30	6:30 - 7:00	7:00 - 7:30	7:30 - 8:00	8:00 - 8:30	8:30 - 9:00	9:00 - 9:30	9:30 - 10:00	.....
Xinzhuang	94	291	998	2435	4609	7675	7733	5376	3250	2034	.....
Road Waihuan	20	53	228	585	1178	2229	2372	1522	854	464	.....
Road Lianhua	36	338	850	1939	3389	5595	5208	4613	2915	1651	.....
Jinjiangleyuan	27	119	315	898	1609	2549	2570	1791	1212	737	.....
South Railway Station	212	145	504	1336	2725	5077	5614	4352	2761	1375	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

Table 2 – The statistics of accumulative frequencies for the start metro stations in each period
(Source from: Liu Xiaochang, 2017)

	5:00 - 5:30	5:30 - 6:00	6:00 - 6:30	6:30 - 7:00	7:00 - 7:30	7:30 - 8:00	8:00 - 8:30	8:30 - 9:00	9:00 - 9:30	9:30 - 10:00	.....
Xinzhuang	0	1	177	720	1644	2166	3071	2485	1514	1404	.....
Road Waihuan	0	0	19	94	337	504	279	232	176	129	.....
Road Lianhua	2	4	113	503	1032	1400	1442	1713	1140	860	.....
Jinjiangleyuan	1	22	58	262	548	816	853	691	543	394	.....
South Railway Station	2	33	154	897	1185	1464	1460	1490	1231	934	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

Table 3 – The statistics of accumulative frequencies for the end metro stations in each period
(Source from: Liu Xiaochang, 2017)

Based on the statistics of accumulative frequencies for the start and end metro stations in each period, the net change of accumulative frequencies in each period can be calculated as shown in the table 4. The value of net change plays a significant role in researching the jobs-housing space structure. For a certain metro station, if the net change is positive value in the morning rush hours and negative value in the evening rush hours, the area in which the station is located is commuters' employment space. Commuters' employment spatial aggregations rise with the value of net change. On the contrary, for a certain metro station, if the net change is negative value in the morning rush hours and positive value in the evening rush hours, the area in which the station is located is commuters' residence space. Commuters' residence spatial aggregations rise with the value of net change.

	5:00 - 5:30	5:30 - 6:00	6:00 - 6:30	6:30 - 7:00	7:00 - 7:30	7:30 - 8:00	8:00 - 8:30	8:30 - 9:00	9:00 - 9:30	9:30 - 10:00	.....
Xinzhuang	-94	-290	-821	-1715	-2965	-5509	-4662	-2891	-1736	-630	.....
Road Waihuan	-20	-53	-209	-491	-841	-1725	-2093	-1290	-678	-335	.....
Road Lianhua	-34	-334	-737	-1436	-2357	-4195	-3766	-2900	-1775	-791	.....
Jinjiangleyuan	-26	-97	-257	-636	-1061	-1733	-1717	-1100	-669	-343	.....
South Railway Station	-210	-112	-350	-439	-1540	-3613	-4154	-2862	-1530	-441	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

Table 4 – The statistics of net change of accumulative frequencies for metro stations in each period
(Source from: Liu Xiaochang, 2017)

3 GENERAL FEATURES OF METRO COMMUTERS

3.1 DATA INTEGRATION

Through some methods such as data mining, data cleansing, data process and data statistic, this research integrates the average weekdays' data of metro commuters. As shown in the figure, x-axis means the different periods with 30-minutes interval in one day from 5:00 am to 23:00, and y-axis means the net change of frequencies in one certain period. The value of net change includes different five subsections, which are from -10000 to -5000, from -5000 to 0, from 0 to 5000, from 5000 to 10000, and from 10000 to 15000.

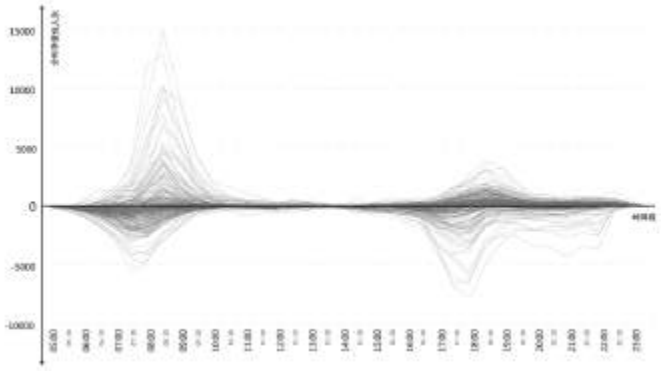

Figure 2 – The statistic of metro commuters in different period (Source from: Liu Xiaochang, 2017)

3.2 WHERE ARE THE METRO COMMUTERS FROM?

Where are the metro commuters from? The answer can be concluded from the value of net change in the morning rush hours and the evening rush hours. As mentioned before, for a certain metro station, if the net change is negative value in the morning rush hours (from 7:30 to 9:30) and positive value in the evening rush hours (from 17:00-20:00). Based on the statistic, the metro stations with top 5 extreme values of net change are Xinzhuang (-5509 in the morning rush hours and 3763 in the evening rush hours), Jiuting (-4664 in the morning rush hours and 3323 in the evening rush hours), Lianhua Road (-4195 in the morning rush hours and 3253 in the evening rush hours), South railway station (-4154 in the morning rush hours and 3155 in the evening rush hours), and Tonghe workers' village (-4074 in the morning rush hours and 2316 in the evening rush hours), as shown in the figure 3.

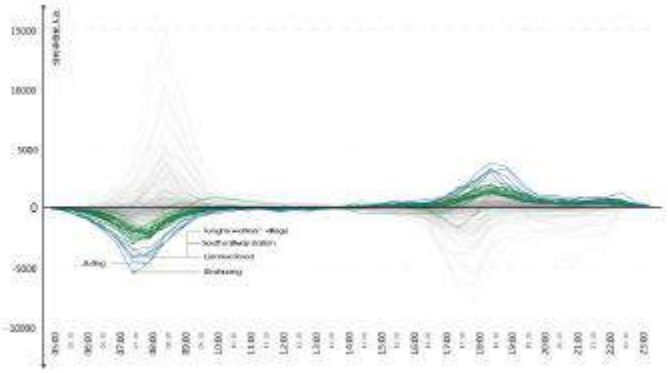

Figure 3 – The statistic of net changes for metro commuters who live near by the stations in different periods (Source from: Liu Xiaochang, 2017)

Meanwhile, the areas in which the stations such as Waihuan Road, Luheng Road, Yangsi, Chengshan Road, Yanggao Road, Jinxiu Road, Fanghua Road, Longyang Road, Century Park, Guanglan Road, Tangzhen, Boxing Road, Shiguang Road, Gongkang Road, Pengpu workers' village, Zhongtan Road, Dahuasan Road, Xingzhi Road, Gucun Park, Taopu workers' village, Nanxiang, Jinyun Road, Beixinjing are located are the significantly typical residence places for the metro commuters, as the blue and green spots shown in the figure 4.

From the distribution of residential spaces, some features can be included: First of all, metro commuters live in between the inner ring and the intermediate ring. Secondly, major metro stations are located within 10km to 15km from the city center, and part metro stations are located within 15km to 20km. In other words, the commuters spend 40 minutes to 60 minutes by metro from their residential spaces to the city center. Last but not least, from the perspective of stations' spatial distribution, the stations are spatially located in the eastern and western sides of Line 2, eastern and western sides of Line 9, the northern and southern sides of Line 1, the northern and southern sides of Line 7, the northern and southern sides of Line 8, the western side of Line 12 and the northern side of Line 5.

Meanwhile, some open-source data such as Baidu Point of Interest (POI) and price of housing from the Fang.com can be used to further demonstrate and analyze the spatial distribution of commuters' residential places as well as the motivation to choose the residential places for the commuters.

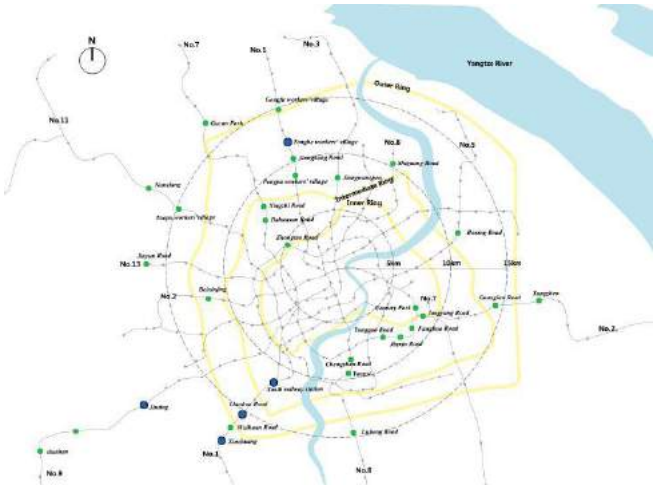

Figure 4 –The resident spatial distribution of metro commuters (Source from: Liu Xiaochang, 2017)

A Baidu POI is a geographic information point with specific coordinators, and it can represent a residential building, a shopping mall, a theater, a metro station, a bus stop, a business building, or a square with its own classification. This part applies the data mining technology based on the Baidu POI with residential attributes. In addition, this part collects the data of average price per square meters of second-hand houses. Although the data of POI and housing price don't have extremely high precision, they are easy to collect with wide coverage. Furthermore, it is an efficient analysis method of spatial structure to do the comparative research based on the same platform including the function, housing price and urban spatial structure.

Therefore, the figure 4 which is the spatial distribution of the areas where the metro stations are located with the typical residence features of residence metro commuters is further analyzed combining the figure 5 which is the spatial distribution of Baidu POI with residential attributes in Shanghai and figure 6 which is the spatial distribution of housing price.

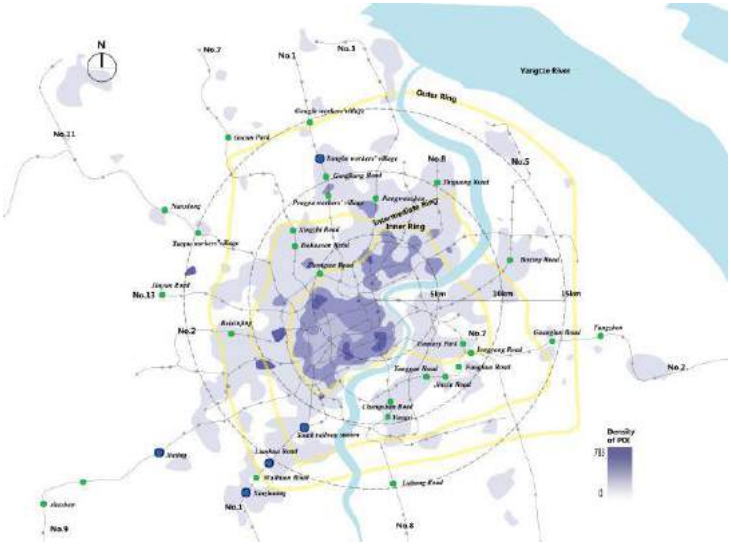

Figure 5 –The analysis of metro commuters` resident style stations overlapping the Baidu POI
(Source from: Liu Xiaochang, 2017)

It can be concluded from the overlay analysis: all the metro stations highlighted based on the data transportation cards are nearly located in the areas with significantly high kernel density of residential POI, as shown in the figure 5. It should be noted that, the density of POI is highest in the city center. However,

there are not highlight metro stations in the city center, the reasons can be found in the figure 6. As shown in the figure 6, the housing price per m²in the city center is at least 50 thousand yuan/m²(approximately 7 thousand Euro/m²), which is not affordable for major commuters. Therefore, residence choice for commuter is a comprehensive process with multi factors such as the time cost and life cost. The commuters are more likely to choose the places with adequate facilities for life (the area with high kernel density in the figure 5), moderate commuting time consumption (40 minutes to 60 minutes by subway, 5km to 15km from commuters' living places to the city center), as well as the affordable and appropriate housing price (from 15 thousand yuan/m² to 35 thousand yuan/m², from 2 thousand Euro/m² to 5 thousand Euro/m²).

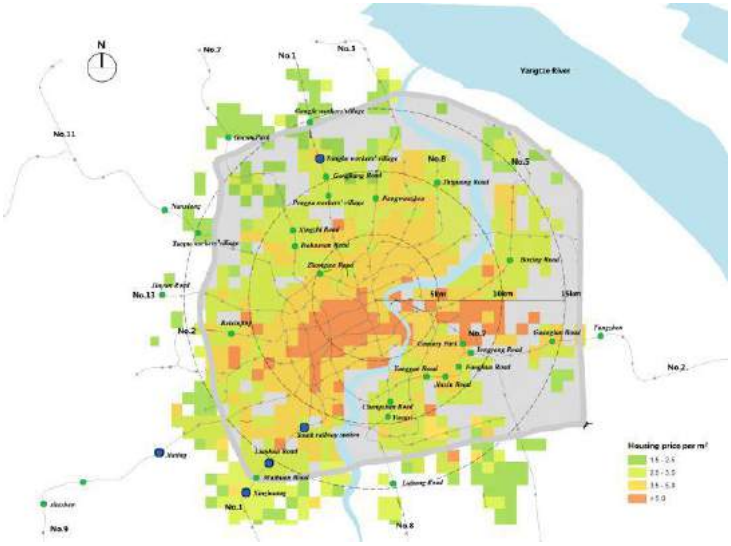

Figure 6 –The analysis of metro commuters` resident style stations overlapping the Housing price
(Source from: Liu Xiaochang, 2017)

In summary, the areas with moderate commuting time consumption, moderate housing prices and sufficient facilities related with residence are along the Line 2 from the city center to the east and west direction, along the Line 1, Line 3, Line 7, Line 8 and Line 11from the city center to the north and south direction. The residential areas of commuters are mainly concentrated around the metro stations such as Waihuan Road, Luheng Road, Yangsi, Chengshan Road, Yanggao Road, Jinxiu Road, Fanghua Road, Longyang Road, Century Park, Guanglan Road, Tangzhen, Boxing Road, Shiguang Road, Gongkang Road, Pengpu workers' village, Zhongtan Road, Dahuasan Road, Xingzhi Road, Gucun Park, Taopu workers' village, Nanxiang, Jinyun Road, Beixinjing, etc.

3.3 WHERE DO THE METRO COMMUTERS GO?

Where do the metro commuters from? The answer can be concluded from the value of net change in the morning rush hours and the evening rush hours. As mentioned before, for a certain metro station, if the net change is positive value in the morning rush hours (from 7:30 to 9:30) and negative value in the evening rush hours (from 17:00-20:00). Based on the statistic, the metro stations with top 5 extreme values of

net change are people's square (14940 in the morning rush hours and -6550 in the evening rush hours), Lujiazui (12892 in the morning rush hours and -7848 in the evening rush hours), Jingan Temple (10004 in the morning rush hours and -5486 in the evening rush hours), Xujiahui (9193 in the morning rush hours and -3811 in the evening rush hours), and East Nanjing Road (7795 in the morning rush hours and -4148 in the evening rush hours), as shown in the figure 7.

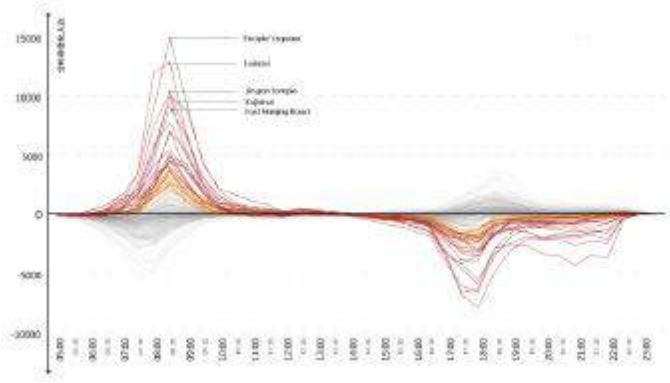

Figure 7 – The statistic of net changes for metro commuters who work near by the stations in different periods (Source from: Liu Xiaochang, 2017)

It should be noted that there are multiple lagging peaks during the evening rush hours, because commuters will spend their evening activities such as dining, recreation and entertainment in the city center that is full of commercial, entertainment and catering facilities until approximately 21:00 p.m. to 22:00 p.m., then they will take subway to go back home. Therefore, as shown in the figure 7, after the evening rush hours (from 17:00 to 19:00), there is a second peak around from 21:00 to 22:00. Although the value of net change of the second peak is not as significantly giant as that of net change of the first one, the figure of the second peak is one second to two thirds of that of the first peak.

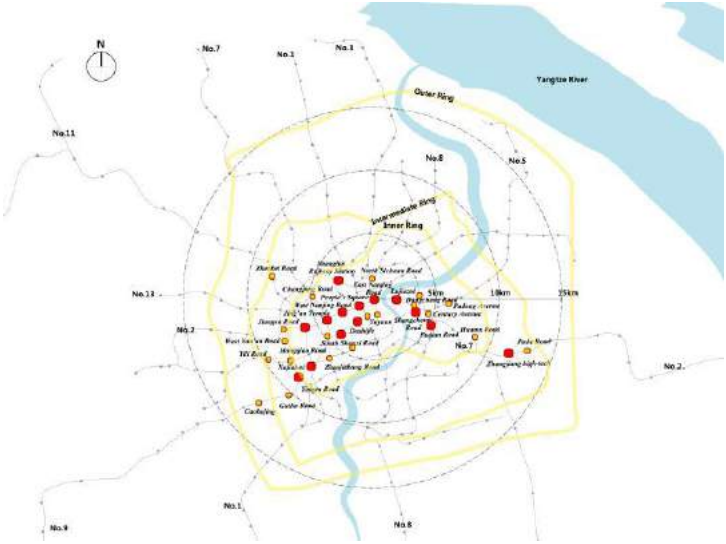

Figure 8 –The working spatial distribution of metro commuters (Source from: Liu Xiaochang, 2017)

Meanwhile, the areas in which the metro stations like North Sichuan Road, Pudong Avenue, Dongchang Road, Shangcheng Road, Century Avenue, Pudian Road, Huamu Road, Jinke Road, Yuyuan, Dashijie, South Huangpi Road, Middle Huaihai Road, South Shanxi Road, Changping Road, Zhenbei Road, Jiangsu Road, West Yan'an Road, Hongqiao Road, Yili Road, Yishan Road, Guilin Road, Caohejing, Zhaojiabang Road, Shanghai Railway Station are located are the typical working places for the metro commuters, as the red and yellow spots shown in the figure 8.

From the distribution of working spaces, some features can be included: First of all, metro commuters work inside the inner ring, and some working places are in between the inner ring and the intermediate ring. Secondly, major metro stations are located within 0km to 10km from the city center, and a part of metro stations are located within 10km to 15km. Similarly, some open-source data such as POI and price of housing from the Fang.com can be used to further demonstrate and analyze the spatial distribution of commuters' working places.

As shown in the figure 9 which is the spatial distribution of POI with office, business, commerce and entertainment attributes, it can be concluded from the overlay analysis: all the metro stations highlighted

based on the data transportation cards are nearly located in the areas with significantly high kernel density of POI with attributes of employment.

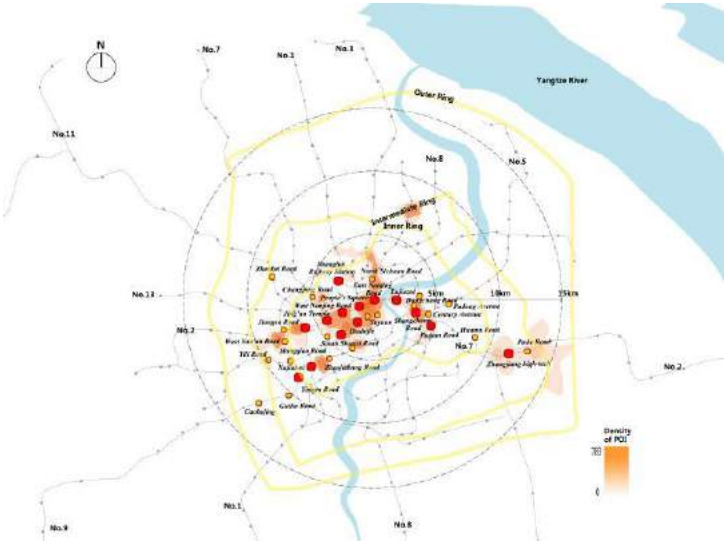

Figure 9 –The analysis of metro commuters` work style stations overlapping the Baidu POI
(Source from: Liu Xiaochang, 2017)

In summary, the working areas for commuters are along the Line 2, Line 9 and Line 10 from the residential areas to city center. The working areas of commuters are mainly concentrated around the metro stations such as North Sichuan Road, Pudong Avenue, Dongchang Road, Shangcheng Road, Century Avenue, Pudian Road, Huamu Road, Jinke Road, Yuyuan, Dashijie, South Huangpi Road, Middle Huaihai Road, South Shanxi Road, Changping Road, Zhenbei Road, Jiangsu Road, West Yan'an Road, Hongqiao Road, Yili Road, Yishan Road, Guilin Road, Caohejing, Zhaojiabang Road, Shanghai Railway Station, etc..

4 TYPICAL FEATURES OF METRO COMMUTERS

4.1 BUS-TRANSFER-METRO COMMUTERS

The Shanghai transportation card is not only available to the subway, but also available to the bus. Therefore, a particular groups who firstly take the bus and transfer metro during the commuting traffic are found in this research. This kind of data account for 20%, which is considerable. In other words, in 100 metro commuter, there are 20 people need to take the bus to transfer subway during the process. It is particularly useful to study the relationship between the bus lines and metro networks, which can provide essential and specific spatial strategies for the development of Shanghai metro systems.

This research classifies the data during the morning rush hours (from 7:30 to 9:30), if one certain transportation card with same ID has a piece of record of bus ride before that of metro one, the owner of this card is 'Bus-Transfer-Metro' commuter, as shown in the table 5 and the figure 10. It is difficult to collect the exact time when the commuters leave the bus, because the commuters will not swipe the card before getting off the bus. However, for all the commuters, they will spend the time in commuting traffic as little as possible, so they will choose the nearest metro station from the bus stop where they get off the bus. Therefore, the time consumption after getting off the bus and before entering the metro station will be ignored. That is to say, the time consumption of commuting traffic by bus is the difference between the time of the time of getting on the bus and entering the metro station.

Card ID	Bus Stop Name (getting on)	Bus Stop Name (getting off)	Time (getting on bus)	Bus commuting time	Metro Station Name (getting on)	Metro Station Name (getting off)	Time (getting on subway)	Time (getting off subway)	Metro commuting time
100052870 6	Changyi Road Luoshan Road	Lujiazui	8:17:07	16 mins	Lujiazui	Jiangsu Road	8:33:10	8:53:54	20 mins
100052620 0	Junlian New Town	Lianhua Road	7:36:26	36 mins	Lianhua Road	People's square	8:12:55	8:44:13	32 mins
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Table 5 –The record of transferring to subway from bus for metro commuters (Source from: Liu Xiaochang, 2017)

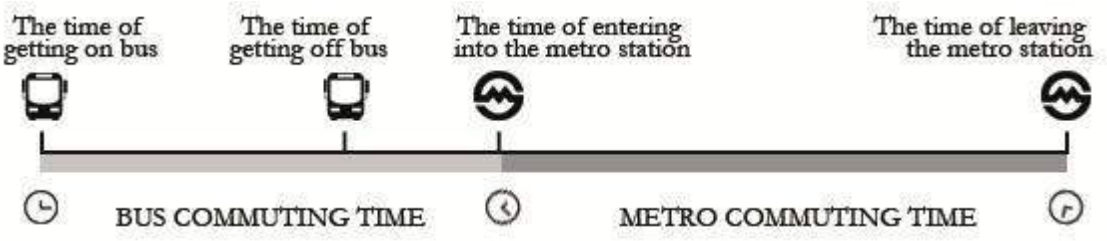

Figure 10 – The diagram of bus-transfer-metro commuters (Source from: Liu Xiaochang, 2017)

This research indicates some typical features of bus-transfer-metro commuters: Firstly, approximately 50% of this kinds of commuters spend about 6 minutes to 18 minutes in commuting traffic of bus, and around 75% of bus-transfer-metro commuters spend less than 30 minutes in commuting traffic of bus. Secondly, as shown in the figure 11, it should be noted that there are 11000 bus-transfer-metro commuters who spend 10 minutes in bus ride before the subway ride in the morning rush hours. Thirdly, with the time consumption of bus commuting increasing from 10 minutes, the amount of bus-transfer-metro commuters sharply decrease, which shows that the commuting mode of selection for the bus-transfer-metro commuters largely depends on the time spent in the bus commuting traffic.

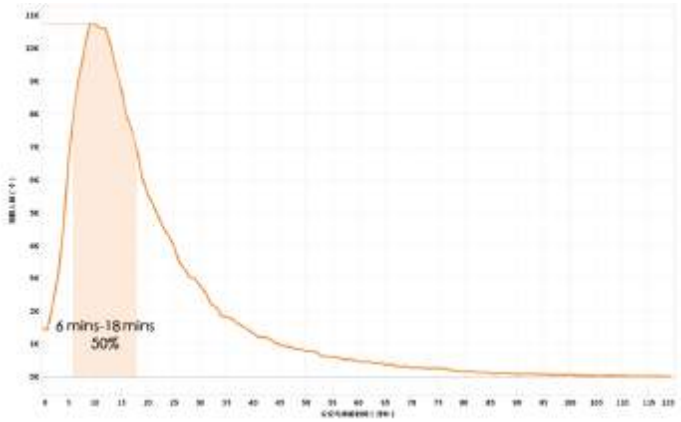

Figure 11 – The relationship between the time spent in bus and the quantity of bus-transfer-metro commuters (Source from: Liu Xiaochang, 2017)

4.2 BUS-TRANSFER-METRO RATE – TAKING THE LUJIAZUI METRO STATION AS AN EXAMPLE

Bus-transfer-metro rate is a ratio to study the situation of bus-transfer-metro commuters in one certain metro station. The bus-transfer-metro rate is the percentage through the quantity of the bus-transfer-metro commuters in a certain metro station dividing by the whole quantity of commuters in the metro station. For example, the bus-transfer-metro rate of metro station A, the rate is: the quantity of bus-transfer-metro commuters in metro station A / the whole quantity of commuters in metro station A. Based on the statistic, there are six metro station with relatively high bus-transfer-metro rate (>50%). They are Lingang Avenue

(86%, 215/250), Xinchang (66%, 1551/2350), Shenshe Road (59%, 6612/11207), Lianhua Road (56%, 9921/11715), Fanghua Road (55%, 4270/7764), and Lujiazui (55%, 3281/5965), as shown in the figure 12.

In the figure 12, the metro stations with relatively high bus-transfer-metro rate are located in the periphery of city center and the suburban areas, because the level of service of metro system in the periphery of city center and the suburban areas is further lower than that of metro system in city center. As for the commuters who live in the peripheral urban areas, the time consumption on foot from their homes to metro station far go beyond their tolerances. Therefore, they select the commuting mode of bus-transfer-metro.

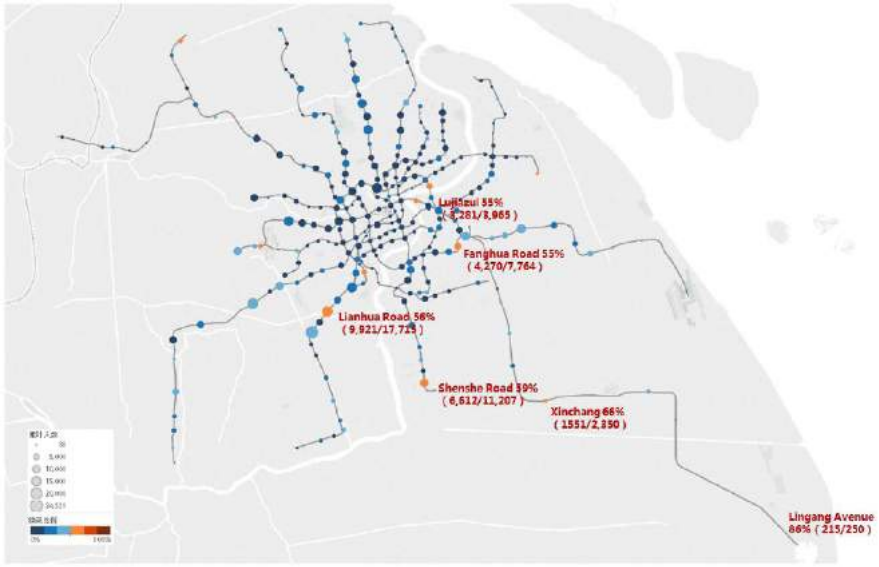

Figure 12 –The spatial distribution of the metro stations with higher bus-transfer-metro rate
(Source from: Liu Xiaochang, 2017)

Beyond expectation, Lujiazui metro station which is located in the city center has high bus-transfer-metro rate with 55%. This research tacks the 55% commuters through their transportation card ID to find the sources before entering into the Lujiazui metro station. It can be concluded that: in the morning rush hours, bus-transfer-metro commuters mainly take Bus No.85 (836), Bus No.971 (325), Bus No.799 (305), Bus No.81 (201), and Bus No. 774 (139) to Lujiazui metro station.

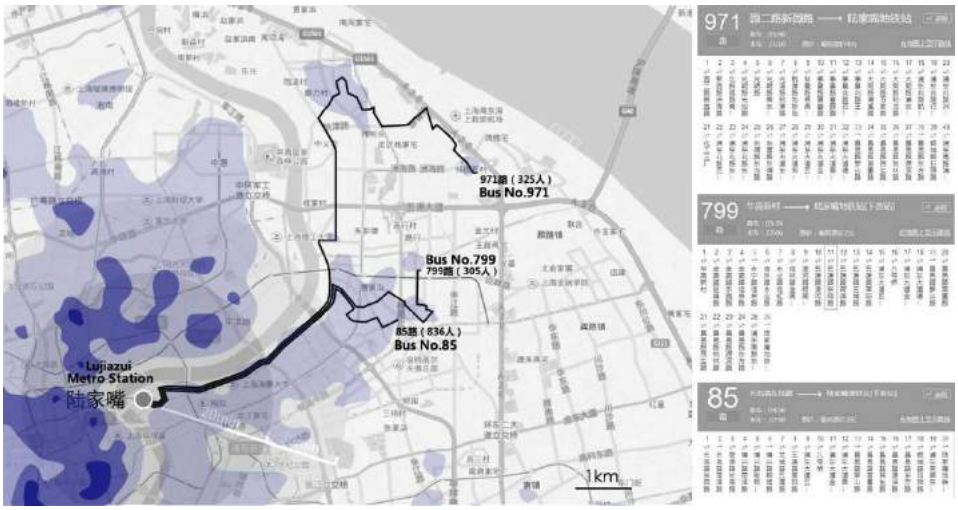

Figure 13 –The spatial distribution of Line Bus No. 85, Bus No. 799 and Bus No. 971
(Source from: Liu Xiaochang, 2017)

From the spatial distribution of the bus lines, some features can be found. Firstly, these buses lines overlap in the Pudong Avenue along the Huangpu River. Secondly, there are massive communities along the

overlapping line such as Jinbang Workers' Village, Longju Huanyuan, Luoshan Workers' Village, Haifang Workers' Village, Linggao Community, Yangjing Garden Town, Huixu-Yayuan, Xishan Community, Haiyuan Community, Meishan Community, Laoshan Workers' Village etc., as shown in the figure 14.

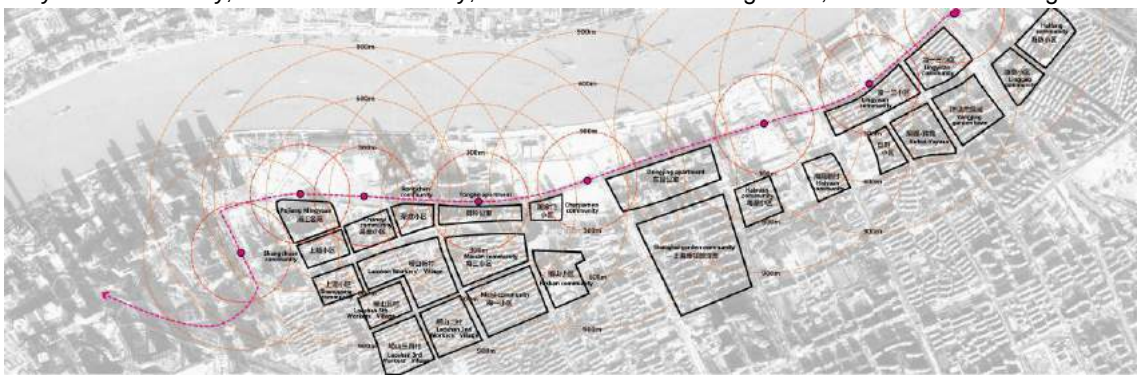

Figure 14 –The residential districts in the buffer of bus stops of Line Bus 85, 799 and 971
(Source from: Liu Xiaochang, 2017)

Meanwhile, based on the interviews of some commuters from these three lines, they gave the similar answers why they chose the bus lines before entering the Lujiazui Metro Station. They said: "We are living the residential areas along the Pudong Avenue. It will take about half an hour, if we walk to the nearest metro station which are about 2 kilometers away from home. You know, 30 minutes are very precious. We want enough time to sleep, especially in the morning. We prefer to spend this 30 minutes in the bed rather than in the way to the metro station. Obviously, we will take bus to metro station. The bus lines are well connected with the Lu jiazui metro station." According to the contents of the interviews, it is lack of accessibility into the metro system for the commuters who live along the Pudong Avenue that is the main reasons why Lujiazui Metro Station located in the city center has the relatively high bus-transfer-metro rate in the morning rush hours.

Therefore, based on this interesting phenomenon, some suggestions like planning a new metro line under Pudong Avenue can be proposed, which will improve service level of subway along the Huangpu River and increase the accessibility into the metro network for the areas along the Pudong Avenue, especially the residential areas. This proposal is demonstrated in the planning and construction of Shanghai rail transit from 2016 to 2020, a new metro line named No.14 will be constructed.

5 SUMMARY

The approaching Big Data era provides totally systematic and quantitative methods. Traffic and passengers flow can be precisely described and analyzed based on the whole sample statistic and database. Although there are still shortages like the metro stations analyzed are not the exact working places and homes of commuters or the data of POI and housing price don't have extremely high precision and so forth, it is an efficient analysis method of research the commuting behaviors based on the same platform including the function, housing price and urban spatial structure. Furthermore, through studying the commuting behaviors, the features of commuting behaviors can be the reasonable and reliable basis of some specific and precise suggestions for the decision-making and policy-setting of metro development in the future.

For the structure of jobs-housing spaces in Shanghai, the working places for metro commuters are along the Line 2, Line 9 and Line 10 from the residential areas to city center. The areas where the metro stations named People's square, Lujiazui, Jing'an Temple, Xujiahui, East Nanjing Road and Zhangjiang High-tech Park are located are the typical working places for commuters.

Meanwhile, owing to the moderate commuting time consumption, moderate housing prices and sufficient facilities related with residence, the residential places for metro commuters are along the Line 2 from the

city center to the east and west direction, along the Line 1, Line 3, Line 7, Line 8 and Line 11from the city center to the north and south direction. The areas where the metro stations named Xinzhuang, Jiuting, Lianhua Road, Shanghai South Railway Station and Tonghe Workers' Village are located are the typical living places for commuters.

In all the metro commuters, there are 20% bus-transfer-metro commuters. For the bus-transfer-metro commuting mode, 75% of the time consumption of bus ride is within 30 minutes. The metro stations with relatively high bus-transfer-metro rate are located in the periphery of city center and the suburban areas, because the level of service of metro system in the periphery of city center and the suburban areas is further lower than that of metro system in city center. As for the commuters who live in the peripheral urban areas, the time consumption on foot from their homes to metro station far go beyond their tolerances. Therefore, they select the commuting mode of bus-transfer-metro.

Besides, like some typical cases like Lujiazui metro station located in the city center with similarly high bus-transfer-metro rate, it can be concluded from the precise and quantitative analysis that the areas along the Huangpu River are lack of accessibility to metro system so that the commuters have to take bus to the nearest metro stations and transfer subway to the working places. Therefore, the bus lines along the river play an important role in commuting traffic for solving the "last one kilometer" problems. The features of commuting behaviors can be the reasonable and reliable basis of some specific and precise suggestions for the decision-making and policy-setting of metro development in the future.

BIBLIOGRAPHIC REFERENCES

[1] Cervero, R. (1996). Mixed Land use and Community: Evidence from the American house survey. Trapn Q, 30(5): 361-377.

[2] Levinson David. Accessibility and the journey to work [J]. Journal of Transport Geography. 1992, 4(2):245-257.

[3] Cuertis C. Can strategic planning contribute to a reduction in car-based travel? [J]. Transport Policy, 1996, 3(1):55-65.

[4] Hanson S. The determinants of daily travel-activity patterns: relative location and socio-demographic factors [J]. Urban Geography. 1982, 3(3): 179-202.

[5] Yanwei CHAI, Zhilin LIU. The temporal and spatial structure of Chinese cities [M]. Beijing: Peking University Press, 2002, 170-173.

[6] Ke WANG. Study on the Influence of Beijing Rail Transportation on the Residence Selection of Commuters [D]. Beijing: Beijing Jiaotong University Press, 2010, 62-64.

[7] Yaping WEI, Conglin, PAN. Study on Land Use Characteristics of Blocks and Commuting Methods in Metropolitan Area – Taking the West Town of Hangzhou as an Example. [J]. Planning Research, 2012, 36(3): 76-89.

[8] Ling QIU. Study on the Influence of Rail Transportation on the Travelling of Inhabitants – Taking Guangzhou as an Example. [D]. Guangzhou: Sun Yat-sen University, 2007, 92-97.