Motorization and Commuting Mode Choice around Metro Stations in Shanghai Central and Suburban Areas

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Abstract

Chinese cities have been witnessing dramatic changes of urbanization and motorization, which brings concerns about congestion, energy overconsumption and air pollution. Rail transit (or MRT) is considered as an effective option to counter or delay motorization. With the extension of urban rail transit from city center to suburban areas, the built environment, transport infrastructure services and travel demand vary greatly. The way how rail transits influence motorization and travel behavior in the central and suburban areas is different. Then policies and planning strategies to reduce car dependency should change accordingly. Based on a household travel survey, we compared the factors influencing car ownership and commuting mode choice of residents with proximity to metro stations in Shanghai central and suburban areas. We found for residents in suburban areas, denser road network at the residential area, more mixed land use and denser road network at workplaces can help to delay car purchasing and reduce car commuting. In the city center however, the built environment characteristics are as significant. The variable, defined as a ratio of access time to station divided by the total travel time by MRT, shows significant influence on residents' decision of rail commuting in both central and suburban areas. Therefore, improvement of access connection to metro stations is an important strategy to attract more passengers. We also found that people's attitude towards MRT have a great impact on motorization and the mode choice of metro.

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INTRODUCTION

Large Chinese cities have witnessed tremendous population growth and immigrations from rural to urban areas in recent decades. Along with population growth and booming economy, the number of cars increased dramatically, which also brought severe traffic congestion, greenhouse gas emissions and air pollution. Rail transit has predominant advantages in owning exclusive routes, promising schedules, and relatively less energy consumption per rider. It is expected to be an attractive alternative for residents owned convenient access to metro. With a high expectation for curbing or delaying motorization, rail transit system was built in two dozens of larges Chinese cities. Besides, many other Chinese cities have aggressive agendas of constructing large scale rail transit systems to connect city central with newly established suburban areas.

Shanghai owns one of the world's largest rail transit systems with continually efforts in transit oriented development. Since the opening of the first Shanghai mass rapid transits (MRT) Line 1 in 1995, 16 MRT lines are in operation now. The differences locations of Shanghai central and suburban areas are correlated with many gaps in the built environment features, the provision of transportation infrastructures and corresponded travel demand. In the central, the population density is much higher and commuting distance is relatively shorter. While in suburban areas, with a shortage of job opportunities, the average commuting distance is enlarged. Now municipal governments are trying to encourage more job opportunities in suburban areas. However, the provisions of public transportation in suburbs lag behind greatly when compared to the central. In other words, the mechanisms of how rail transit systems influence motorization in central and suburban areas may be quite different.

Therefore, policies and planning strategies in reducing the car dependence should adapt to the built environment accordingly. We are aimed at exploring the differences of how the rail transits influence motorization around metro station areas in the central and suburban areas respectively. This study tries to offer insights on evaluating the connections and divergences resulted from central and suburban areas given rail transit proximity. The conclusions may offer some recommendations for the forthcoming planning practice of integrated transportation and land use in large Chinese cities, as well as for cities in the other developing world facing similar pressures from population, urbanization and motorization.

2 LITERATURE REVIEW

In the recent three decades, travel characteristics in Chinese large cities have been changing to longer distances and shifting from non-motorized to motorized modes. In 1997, Shen proposed that enhancing accessibility without inducing additional motorized travel demand should serve as a basic guideline for integrated land use and transportation planning *(1).*

Public transportation, especially rail transit development, is expected to be effective measure in reducing car dependence. Large cities as Beijing and Shanghai attempted to guide city expansions through transit oriented development (TOD). Interestingly the outcomes of changes in travel demand after the implementation of TOD in these Chinese cities are quite different. The improvements in proximity and convenience to metro allowed station areas' residents and employees to involve in their daily activity within a smaller space corresponded to shorter travel distances, lower average vehicle trip rates, as noted by Bartholomew *(2)*. In 2008, Cervero and Day *(3)* conducted a current and retrospective survey on residents who relocated to three selected suburban neighborhoods in Shanghai to examine the impacts of relocation on the changes of commuting mode choice and travel duration. They found that the level of motorized travel and average commute durations of relocated residents increased substantially, along with decreased job accessibility.

In terms of the association between urban forms, job accessibility and transportation mode choice, consistent results were confirmed by many researches. In a study of urban expansion and transportation consequences, Zhao *(4)* noticed that urban growth on the fringe of Beijing was characterized by low density and dispersed development, as well as low degrees of mixing land use. This pattern was associated with longer trip distance and higher car dependence. He argued that urban growth management would help to mitigate the trend of motorization in the suburbs. In a recent paper, Yang and his co-authors *(5)* used three decades census data to describe Beijing's spatial development and conducted a household survey to assess its transportation impacts. Their empirical results indicated that over-concentrated jobs and housing stemming from featureless expansion of the central built-up area leaded to an increase in commuting duration and congestion. In 2014, by examining the relationship between jobs-housing balance and commuting mode choice of Beijing, Pan and Ge found that in the peripheries, the commuting distance and time increase greatly because of the decrease of job accessibility *(6).*

The proximity to a rail transit station and mode choice is another interesting topic in this field that many studies had explored the correlations between rail transit accessibility and travel behavior. Many studies argue that residents of high-density neighborhoods where transit is easily and efficiently accessible tend to drive less *(7, 8, 9)*. Cervero and Duncan *(10)* found that rail transit had impact on commuting mode choice on relocated residents. Based on the travel data of San Francisco Bay area in 2000, they found that within 0.5 miles to metro stations, the commuting mode share of rail transit was about 40%. It confirmed that the proximity to rail transit improved the transit ridership.

In different cases, the result turned to be quite different. According to Chatman *(11)*, auto commuting and car ownership were strongly correlated with housing types and tenure, as well as the amount of available parking, and less impacted by rail station proximity. By applying a binary logistic regression, Pan and Ge *(6)* found that in Beijing people commuting by rail transit was significantly influenced by whether they lived and worked along the rail transit corridors, which indicated that both home and workplace locations were both within one kilometers away from the nearest rail transit station. It suggested that the proximity of the workplace to metro station can also influence one's commuting mode choice.

By examining car ownership and commuting mode choice of residents living near metro stations in suburban areas, Pan and Shen *(12)* found that rail transit helped to delay the pace of motorization among households near suburban metro stations and lowering the probability of driving in commuting trips. They also found that car ownership had been increasing quite rapidly despite the positive effects of a much expanded and improved metro system. Once a person owned a car, she or he was mostly drive to work.

In previous studies, the impacts of other factors like built environment and socio demographic characteristics on travel behavior were also well documented. Boarnet *(13)* found that regional average built environment may mask many localized impacts which affected individual travel decisions. Nasri and Zhang *(14)* found that as the consequence of improved mobility, travel behavior has become more connected to large-scale land-use and the overall spatial form of metropolitan.

Thus, combining micro level measured built environment features with regional elements are more desirable for travel behavior studies. Ewing suggested 6Ds to measure built environments: design, diversity, density, destination accessibility, distance to transit and demographics. He found built environment was important in explaining vehicle miles traveled, trip generation and trip length *(15).* Residents of newly developed neighborhoods in suburban areas were found to have higher degrees of car ownership, spent more time on daily travel and made longer trips than those of traditional neighborhoods *(16, 17).*

Because of the differences in built environment, transportation infrastructure provisions, and residents' socioeconomic profiles between the central and suburban areas in Shanghai, the characteristics of commuting trips are assumed to have great variations. Thus, we attempt to evaluate the variations of how the rail transits influence motorization around metro stations in the central and suburban areas for planning and policy indications.

3 RESEARCH QUESTIONS AND METHODOLOGY

3.1 Research Questions

In this study, we compared the degrees of motorization around metro stations in the central and suburban areas of Shanghai to gain insights of how to reduce car ownership and driving. Specifically, it attempted to focus on the following three questions: (1) What were the differences of commuting trip characteristics of residents with proximity to metro stations in the central and suburban areas? (2) How did rail transit influence households' car ownership near rail station areas; (3) How did rail transit influence commuting mode choice of residents with rail transit proximity?

3.2 Methodology

A household travel survey was conducted around selected metro stations in central and suburban areas in October 2013. In Shanghai, the biggest influencing area of rail transit stations in the city center is less than 2km and the biggest influencing area in the suburban area is less than 3km. For the residents living outside of the influencing area, there probability of people traveling by metro is trivia. So in this study we used a 3km radius around metro stations in suburban area and a 2km radius around stations in the city center as the sampling areas. The selected stations and the corresponded sample size are displayed in Figure 1.

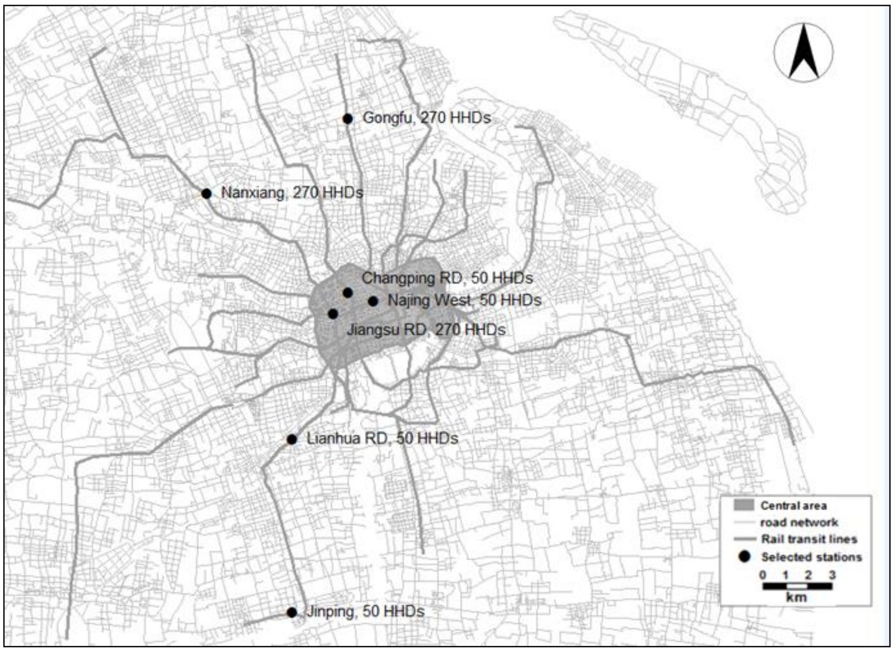

Figure 1 Location of selected stations

There were 1018 and 574 randomly selected residents (619 and 342 valid household samples) surveyed in central and suburban areas respectively. Through the questionnaire, we obtained the socio demographic information of the residents, home and workplace locations, attitudes about car or MRT, and recent travel behavior characteristics. The built environment variables are calculated then according to the residential location and the workplace of the respondents.

The local built environment characteristics around home and workplace locations were measured by three factors: population density, road density and land use mixture, as listed in Table 1. These three factors were obtained by spatial overlay based on the GIS profiles of Shanghai in central and suburban areas. The land use mixture was derived from Shannon entropy. The radius used for this analysis was 500 meters. There were five primary land use categories, including residential, commercial, industrial, transportation and open space in calculating this index. The percentage of each land use is defined as Pi (Pi= Ai/A), where Ai/A referred to the percentage of a specific land use type inside the 500m buffer, expressed in Equation 1.

$$H = -\sum_{i=1}^{N} (Pi) \ln (Pi) \qquad (1)$$

The variables of transportation infrastructure provision are also displayed in Table 1. They were objectively measured through spatial analysis by three layers: home and workplace locations, road network and rail transit system

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Table 1. Variable dictionary

Categories	Variables	Abbreviations	Values and Descriptions
Individuals' and households' SES	MRT intention	MRT	=1 if the respondent reported in the questionnaire she or he preferred MRT if the commuting times of MRT and car were the same, otherwise 0.
	Avg. MRT intention	AMRT	Continuous variable. The average of the MRT preference of the working family members.
	Household income (k)	HHDINC	Continuous variable. Annual household income (10^3 ¥)
	Annual income (k)	AINC	Continuous variable. Annual personal income (10^3 ¥)
	Age	AGE	Continuous variable.
	Gender	Gender	=1 if gender is male, otherwise 0.
	Occupation	OCCUP	=1 if the occupation if highly skilled job, otherwise 0.
Transportation infrastructure provision	Commuting distance of the road network (km)	CDRN	Continuous variable. It is obtained by applying the shortest path analysis in the GIS package after geo coding of the residential area and workplaces of the respondent.
	Proximate to metro station	PROX	=1 if the residential area is within 500m of the metro station.
	Time in metro system (minutes)	TIMV	Continuous variable. It was obtained by shortest path analysis in the GIS package. The time was obtained according to the schedule table from Shanghai metro.
	Access time to station	ATTS	Continuous variable. In the central area, walking access time was obtained by shortest path analysis. In the suburban areas, it was based on the same analysis but on different access modes.
	Egress time from station	ETFS	Continuous variable. Access time was obtained by applying the shortest path analysis by walking.
	Total commuting time	TCTM	Continuous variable. The time in metro plus access/egress time.
	Ratio of local access time divided by total MRT commuting duration	RATTS	Continuous variable. The ratio of the access time before entering the beginning station.

	Ratio of local egress time divided by MRT commuting total duration	RETFS	Continuous variable. The ratio of the access time after leaving the last station.
Built environment	home population density (k)	RPOPD	Continuous variable. The population density at homes. (10^3 people per square kilometers)
	home road density (km/km2)	RRND	Continuous variable. The sum of road length divided by the area at homes. (The radius is 500 meters)
	home land use mixture	RML	Continuous variable.
	workplace population density (k)	WPPD	Continuous variable. The population density at work places (10^3 of people per square kilometers)
	workplace road density (km/km2)	WPRND	Continuous variable. The sum of road length divided by the area at workplaces. (The radius is 500 meters)
	workplace land use mixture	WPML	Continuous variable.
	Avg. workplace population density (k)	AWPPD	The average workplace population density of employed family members.
	Avg. workplace road density (km/km2)	AWPRND	The average workplace road density of employed family members.
	Avg. workplace land use mixture	AWPML	The average land use mixture of employed family members.

4 EMPIRICAL ANALYSIS

4.1 Commuting characteristics

The data shows in the central the average commuting distance is shorter, which is only 5.8 km, while in suburban areas the average commuting distance is almost doubled to 10.4 km. however there is not much difference in modal shares between MRT in central and suburban areas, but residents in suburban areas have higher car dependence. Among the respondents living in the city center, the probability of commuting by car is much lower and probability of commuting by metro is much higher. As shown in Figure 2.

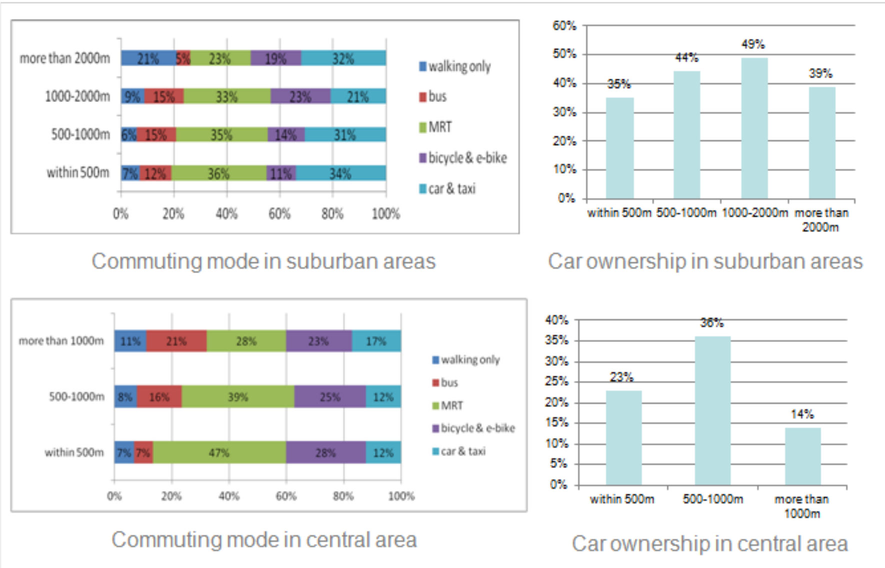

Figure 2. Car ownership and commuting mode choice by proximity to closest MRT stations

Suburban MRT commuters spent more time in commuting than MRT commuters in the city center and the access time to stations were much longer. 95.3% of the MRT commuters in the city center walked to the stations while in the suburban area the percentage was about 57.0%. Because of the longer access distance of stations in suburban areas, biking, bus and driving are also very important access modes.

4.2 Car ownership of the central and suburban areas

To examine the difference of the factors influencing households' car ownerships in the city center and suburban areas, a binary logistic model was applied. A descriptive analysis of variables involved is listed in the following Table 2.

Table 2. Variables descriptive analysis

Variables	value & description	suburban areas		central area	
		cases	Percentage	cases	percentage
Car ownership	0, no	346	55.9	263	76.9
	1, yes	273	44.1	79	23.1
Proximate to metro station?	0, no	513	82.9	254	74.3
	1, yes	106	17.1	88	25.7
Total		619	100.0%	342	100.0%

Variables	suburban areas				central area			
	min	max	average	sd	Min	max	average	sd
household income(k)	20	500	149.05	77.857	20	375	113.60	56.784
home population density(k)	1.611	8.035	4.387	2.817	5.727	40.242	26.180	11.029
home road density (km/km^2)	.449	10.915	5.601	2.564	4.643	54.200	14.099	12.588
home land use mixture	.157	1.316	.583	.335	.048	.653	.219	.152
Avg. workplace population density (k)	.000	71.678	14.690	14.320	.959	75.864	20.974	13.589
Avg. workplace road density (km/km^2)	1.910	14.656	5.820	2.065	2.851	96.593	13.483	14.473
Average workplace land use mixture	.000	1.502	.501	.360	.020	1.413	.362	.315
Avg. MRT preference	0	1	.56	.438	.0	1.0	.718	.414

The result shows household income has a significant positive influence on car ownership. The MRT preference of the household shows a significant negative effect on car ownership. But the proximity to MRT station does not have any impact on car ownership in Shanghai.

Among the respondents in the suburban areas, the road density and land use mixture of the workplaces both have significant effects on car ownership. Denser road network and more mixed land use related to lower level of car occupation. But in the central area, the effect of the road density and the land use mixture were less significant. In the city center, people's decision of car ownership is mainly influence by their attitudes towards MRT commuting and household income. For those living in suburban areas, however, this decision is not only based on these two factors, but also related to the workplace built environment features.

Table 3. Binary logit model of car ownership in suburban and central areas

Variables	Suburban areas					Central area				
	B	S.E.	Wals	Sig	Exp (B)	B	S.E.	Wals	Sig	Exp (B)
Household income	.015	.002	69.609	.000	1.015	.021	.003	38.694	.000	1.021
MRT intension	-1.390	.220	39.849	.000	.249	-1.972	.419	22.158	.000	.139
Proximate to metro station	-.143	.266	.289	.591	.867	-.262	.471	.310	.578	.769
home pop. density	-.028	.041	.464	.496	.972	.038	.051	.540	.462	1.039
home road density	-.028	.041	.458	.498	.972	.013	.048	.075	.784	1.013
home land use mixture	.372	.373	.992	.319	1.450	1.326	1.240	1.142	.285	3.764
workplace pop. density	-.007	.008	.748	.387	.993	.010	.015	.446	.504	1.010
workplace road density	-.110	.055	4.017	.045	.896	.032	.019	2.948	.086	1.033
workplace land use mixture	-.760	.343	4.916	.027	.468	.394	.540	.531	.466	1.482
Constant	-.438	.596	.540	.462	.645	-4.928	2.167	5.170	.023	.007
Goodness of fit	*Selected Cases: 619; Cox & Snell R Square: 0.240; Nagelkerke R Square: 0.321; Correctly Predicted: 71.1%*					*Selected Cases:342 ; Cox & Snell R Square: 0.293; Nagelkerke R Square: 0.444; Correctly Predicted: 82.5%*				

4.3 Commuting mode choice of residents proximate to metro stations

Multinomial logit regression was applied to examine the factors influencing the residents' commuting mode choices in the city center and suburban area. The variables included residents' attitude toward MRT, age, gender, personal annual income, occupation, objectively measured built environment and objectively transportation infrastructure characteristics.

Table 4. Descriptive analysis for multinomial logit regression of commuting mode choice

Variables	value & description	suburban areas		Central area	
		cases	percentage	cases	percentage
commute mode	1, walk only	73	7.2%	54	9.4%
	2, bus	121	11.9%	67	11.7%
	3, MRT	344	33.9%	220	38.3%
	4, bike & e-bike	221	21.8%	149	25.9%
	5, car	256	25.2%	85	14.8%
Gender	0, female	440	43.3%	262	45.6%
	1, male	575	56.7%	313	54.4%
Occupation	0, low skilled profession	63	6.2%	35	6.1%
	1, higher skilled profession	952	93.8%	540	93.9%
Total		1015	100.0%	575	100.0%

Variables	suburban areas				Central area			
	min	Max	average	sd	min	max	average	sd
AINC	20	250	66.48	45.857	20	175	57.29	39.399
TIMV	0	83	20.49	19.331	0	57	12.91	10.573
RATTS	.0156	.9855	.3407	.1610	.0383	.9873	.3814	.1735
RETTW	.0002	.9332	.3639	.2506	.0008	.8262	.2998	.1884
CDRN	.026	62.795	10.374	8.601	.042	34.882	5.794	5.143
RPOPD	1.611	8.035	4.417	2.812	5.727	40.242	26.083	10.862
RRND	.449	10.915	5.576	2.541	4.643	54.200	14.011	12.510
RML	.157	1.316	.574	.335	.048	.653	.217	.152
WPPD	.000	75.864	14.577	16.080	.813	75.864	21.160	15.248
WPRND	1.781	18.116	5.792	2.407	1.720	96.593	13.716	15.806
WPML	.000	1.502	.500	.390	.020	1.449	.367	.374

To identify the influence of access to MRT station on mode choice, the following factors were included: time spent in metro (TIMV), the ratio of access time from home to station divided by the total MRT commuting duration (RATTS), and the ratio of the egress time from station to workplaces divided by the total MRT commuting duration (RETFS). MRT commuting time was the sum of access time, time in metro and egress time. Time in metro was counted based on the time table of Shanghai metro

The result is displayed in Table 5. In both Shanghai central and suburban areas, residents with a preference towards MRT and lower annual income were more likely to commute by metro. While comparing the estimated coefficients, MRT intension had relatively bigger influence and income had relatively smaller effect on commuting mode choice of MRT instead of car in the central area. So with the same increase in income, there would be less mode shift from metro to car in city center than in suburban areas.

In both the city center and suburban area, longer commuting distance, shorter time in metro, smaller ratio of access/egress time leaded to more metro trips. With the same travel distance, better metro proximity and shorter time consumed in metro also improved the popularity of metro. Therefore, the improvement in access connection to a station was very important to attract passengers. In the city center, increasing the station density can help reduce the access/egress time and encourage the mode shift from car to rail transit. Comparing the coefficients of the ratio of access/egress time, egress time had a bigger influence on mode choice than access time.

In the suburban areas, residents' choice of commuting by metro was also significantly influenced by road network at homes and land use mixture at workplaces. Denser road network at home and more mixed land use at workplaces were associated with more metro commuting instead of car. While in the city center, neither of these two factors was significant, maybe because in the city center the two indicators were relatively high.

Table 5. Coefficients of the multinomial Logit Model for commuting mode choice

Reference level: commuting by car

mode	variables	Suburban areas					Central area				
		B	S.E.	Wald	SIG	Exp(B)	B	S.E.	Wald	SIG	Exp(B)
rail transit	CONSTANT	2.087	1.227	2.893	.089		6.852	2.191	9.779	.002	
	MRT	2.261	.260	75.734	.000	9.595	2.450	.411	35.478	.000	11.592
	AINC	-.022	.003	48.815	.000	.978	-.019	.004	22.198	.000	.981
	AGE	-.008	.011	.435	.509	.993	.022	.014	2.372	.124	1.022
	Gender(0)	.535	.263	4.148	.042	1.708	.338	.343	.970	.325	1.403
	Occupation(0)	-.758	.606	1.563	.211	.469	-1.789	.719	6.194	.013	.167
	CDRN	.242	.036	46.405	.000	1.274	.160	.077	4.299	.038	1.174
	TIMV	-.118	.020	34.083	.000	.889	-.098	.044	4.858	.028	.907
	RATTS	-4.322	1.485	8.467	.009	.013	-3.892	2.171	3.214	.073	.020
	RETFS	-7.806	1.131	47.619	.000	.000	-7.525	1.477	25.953	.000	.001
	RPOPD	.041	.051	.652	.419	1.042	-.062	.055	1.258	.262	.940
	RRND	.103	.055	3.518	.061	1.108	-.043	.050	.735	.391	.958
	RML	.265	.506	.275	.600	1.304	-1.433	1.265	1.285	.257	.238
	WPPD	.011	.010	1.115	.291	1.011	-.016	.013	1.437	.231	.984
	WPRND	.041	.053	.605	.437	1.042	-.002	.015	.028	.868	.998
	WPML	.667	.361	3.410	.065	1.949	-.439	.476	.850	.357	.645
bus	CONSTANT	-5.662	1.628	12.094	.001		.959	2.650	.131	.718	
	MRT	1.349	.255	28.070	.000	3.854	1.523	.516	8.717	.003	4.586
	AINC	-.018	.003	30.358	.000	.982	-.021	.005	15.194	.000	.979
	AGE	.023	.011	4.571	.033	1.024	.030	.017	3.215	.073	1.030
	Gender(0)	.238	.266	.801	.371	1.269	.962	.418	5.293	.021	2.617
	Occupation(0)	-1.840	.779	5.580	.018	.159	-21.648	.000	.	.	3.96E-10
	CDRN	-.073	.025	8.516	.004	.930	-.179	.107	2.815	.093	.836
	TIMV	.055	.015	13.658	.000	1.057	.090	.055	2.642	.104	1.094
	RATTS	4.121	1.730	5.676	.017	61.649	5.415	2.679	4.084	.043	224.690
	RETFS	4.496	1.427	9.922	.002	89.666	1.919	1.852	1.073	.300	6.812
	RPOPD	.043	.052	.697	.404	1.044	-.104	.063	2.674	.102	.902
	RRND	-.031	.054	.332	.565	.969	-.183	.062	8.570	.003	.833
	RML	.675	.521	1.678	.195	1.964	-2.592	1.625	2.545	.111	.075
	WPPD	.025	.011	5.343	.021	1.025	-.008	.015	.312	.576	.992
	WPRND	.038	.065	.342	.559	1.039	.057	.022	6.542	.011	1.059
	WPML	.300	.407	.544	.461	1.350	1.032	.545	3.583	.058	2.807
walk	CONSTANT	-313.0	1.866	28137.67	.000		4.284	6.706	.408	.523	
	MRT	1.512	.422	12.832	.000	4.537	.962	.670	2.063	.151	2.618
	AINC	-.030	.008	14.372	.000	.971	-.039	.011	13.534	.000	.962
	AGE	-.006	.017	.121	.728	.994	.032	.021	2.317	.128	1.033
	CDRN	-1.243	.306	16.463	.000	.289	-3.459	.588	34.558	.000	.031
	TIMV	1.427	12.68	.013	.910	4.167	.433	.180	5.763	.016	1.542
	RATTS	312.4	1.41	49002.9	.000	5.0E+1	10.91	6.326	2.978	.084	55037.5

		6	2	5		35	6				
	RETFS	312.29	.000	.	.	4.2E+135	6.123	5.956	1.057	.304	456.029
	RPOPD	.357	.198	3.264	.071	1.429	-.202	.118	2.927	.087	.817
	RRND	.155	.127	1.507	.220	1.168	-.057	.120	.225	.635	.945
	RML	-.049	.894	.003	.956	.952	-.878	2.325	.143	.706	.415
	WPPD	.048	.170	.079	.779	1.049	.008	.027	.100	.752	1.008
	WPRND	.327	.144	5.111	.024	1.386	-.120	.093	1.673	.196	.887
	WPML	.153	.922	.028	.868	1.166	2.304	1.380	2.787	.095	10.012
	Gender(0)	.116	.427	.074	.785	1.123	.426	.552	.597	.440	1.532
	Occupation(0)	-.170	.673	.064	.801	.844	-1.753	.963	3.315	.069	.173
Bicycle & e-bike	CONSTANT	-6.543	2.014	10.555	.001		.011	2.733	.000	.997	
	MRT	.878	.245	12.821	.000	2.406	1.455	.476	9.346	.002	4.283
	AINC	-.017	.003	34.364	.000	.983	-.034	.006	33.509	.000	.967
	AGE	.068	.011	39.607	.000	1.070	.089	.016	31.308	.000	1.093
	CDRN	-.256	.039	42.576	.000	.774	-.709	.137	26.828	.000	.492
	TIMV	.042	.018	5.472	.019	1.043	.158	.063	6.264	.012	1.171
	RATTS	5.400	2.004	7.262	.007	221.365	6.050	2.803	4.658	.031	424.307
	RETFS	4.693	1.777	6.977	.008	109.165	3.936	2.092	3.539	.060	51.223
	RPOPD	.065	.053	1.463	.226	1.067	-.089	.061	2.097	.148	.915
	RRND	.112	.055	4.167	.041	1.119	-.143	.060	5.688	.017	.866
	RML	-.066	.475	.019	.890	.936	-.711	1.595	.199	.656	.491
	WPPD	.016	.012	1.741	.187	1.016	-.012	.015	.653	.419	.988
	WPRND	.063	.068	.849	.357	1.065	.047	.023	4.349	.037	1.048
	WPML	.636	.400	2.534	.111	1.889	1.114	.586	3.610	.057	3.046
	Gender(0)	-.021	.260	.006	.936	.979	-.250	.403	.384	.536	.779
	Occupation(0)	-.921	.419	4.830	.028	.398	-1.423	.733	3.768	.052	.241
Goodness of fit		Cox & Snell R Square: 0.747; Nagelkerke R Square: 0.787.					Cox & Snell R Square: 0.725; Nagelkerke R Square: 0.765.				

. CONCLUSIONS

Prior studies showed that rail transit was competitive in terms of travel time. The intention of commuting by rail transit, along with proximity from home or workplaces to MRT stations, may reduce the probability of driving over riding metro. In this study, we further explored the factors influencing car ownership and rail transit modal share of residents with the proximity to metro stations in city center versus suburban areas of Shanghai. Our conclusions are listed as follows:

Firstly people's intention to use MRT has negative effects on mode choice of driving and car ownership. In the city center, only residents' attitude towards MRT and their income had effects on whether to purchase a car. Compared with people in suburban areas, people's attitude towards MRT had greater influence on their choice of commuting by metro or car. Secondly, this study also confirmed the impact of regional and local built environment on motorization. Except for income and attitude towards MRT, suburban resident's car ownership is also influenced by built environment characteristics, which means denser road network and more mixed land use at workplaces may result in less car purchasing. Thirdly, given the same commuting distance, residents are more likely to commute by rail transit instead of car if the ratio of access time from home/job to station is smaller. So the improvement of access to metro stations is very important to attract passengers. Shorter distances between stations or higher station density in city center also encourage residents to take metro.

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