Hindawi Publishing Corporation
Mathematical Problems in Engineering
Volume 2013, Article ID 620973, 9 pages
http://dx.doi.org/10.1155/2013/620973

Research Article

Analysis on Residents' Travel Activity Pattern in Historic Urban Areas: A Case Study of Historic Urban Area of Yangzhou, China

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Received 12 September 2013; Revised 4 November 2013; Accepted 21 November 2013

Academic Editor: Wuhong Wang

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Travel behaviors and activity patterns in the historic urban area of a city are expected to be different from the overall situations in the city area. The primary objective of this study is to analyze the residents' travel activity patterns in historic urban area. Based on survey data conducted in the historic urban area of Yangzhou, the travel activities of local residents in a whole day were classified into five types of patterns. The multinomial logit (MNL) model was developed to evaluate the impacts of explanatory variables on the choices of activity patterns. The results showed that the choice of activity pattern was significantly impacted by five contributing factors including the gender, age, occupation, car ownership, and number of electric bikes in household. The other variables, which were the family population, preschoolers, number of conventional bikes in household, motorcycle ownership, and income, were found to be not significantly related to the choice of activities. The results of this study from historic urban area were compared to findings of previous studies from overall urban area. The comparison showed that the impacts of factors on activity pattern in the historic urban area were different from those in the overall area. Findings of this study provide important suggestions for the policy makings to improve the traffic situations in historic urban areas of cities.

1. Introduction

In the past decade, cities in China have experienced extremely large changes in their appearances and land use patterns. A number of new buildings and new road facilities were built in the city area. However, to keep the features of old buildings and save the panorama of history of the city, the historic urban area in a city has not been changed too much in the past years. Generally in China, the historic urban area is not only the concentrated residential area but also the political, commercial, and cultural center of the city. The historic urban area has a high population density, mixed land use pattern, and multiple types of travel activities. Thus, currently in cities of China, the historic urban areas are experiencing extremely severe traffic congestions as compared to other areas in cities. An analysis on the travel activity patterns in historic urban areas could help transportation planners better understand the characteristics of travel activities and develop strategies to reduce the congestions in such areas.

Traditionally, the aggregate methods such as the Four-Stage Method were commonly used to analyze the characteristics of travel activities [1–3]. However, the aggregate methods were based on the traffic analysis zone (TAZ) level which cannot reflect the travel behaviors of certain people in a certain area. Then the disaggregate modeling techniques, such as MNL model, MNP model, and NL model, were developed by researchers to model the travel behaviors in certain areas at an individual level [4–18]. The models developed in previous studies can be used to make a prediction on the decision of an activity or trip mode for an individual traveler in a single trip. Actually, however, travelers usually plan their travel activities with multiple purposes or destinations in a whole day simultaneously.

In recent years, many researchers have recognized the importance of multitrip patterns in travel behavior analysis. A sequence of multiple travel activities was descripted as an activity pattern or trip chain in previous studies [19–28].

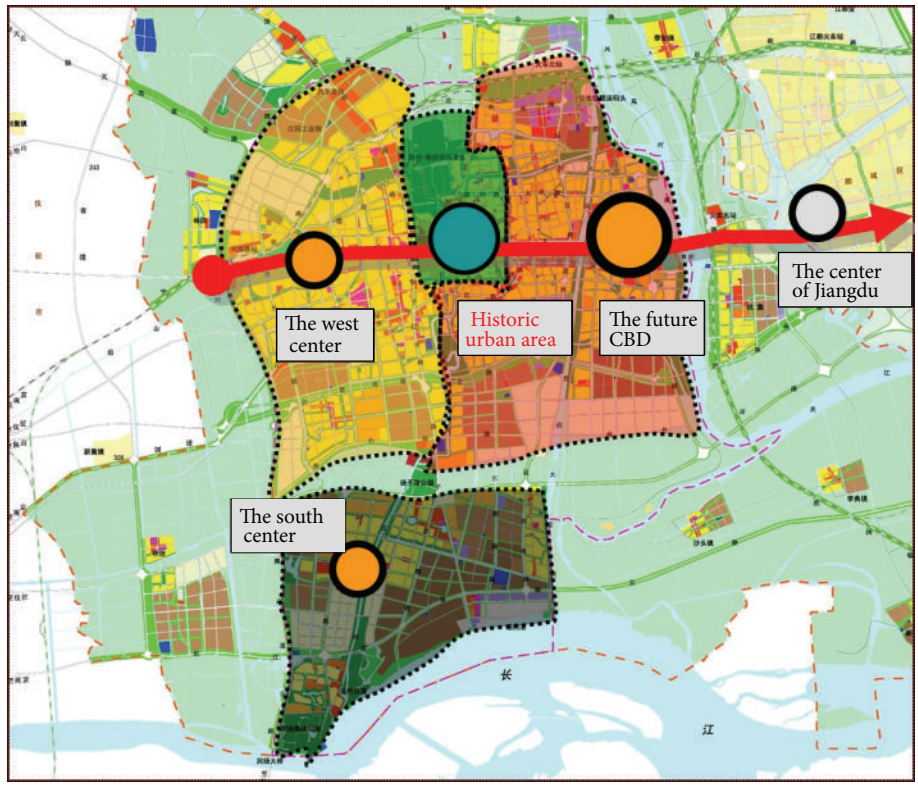


Figure 1: The location of historic urban area of Yangzhou.

The disaggregate modeling techniques were commonly used in the analysis of trip arrangement [9–17], trip route choice [10, 11], activity choice [18, 20, 21, 25], and trip chain pattern [19, 22–24, 27]. These studies have shown that the analysis on travelers' activity pattern (i.e., trip chains) can provide important information for transportation researchers and planners to understand the travel behaviors of travelers and improve the transportation system in city areas. The factors impacting individuals' travel behaviors include the sociodemographic characteristics, physical environments, attitudinal factors, and travel-related features. Some other factors such as land use pattern and road facility were also found to affect the residents' travel behaviors [29–33].

A review on the literature shows that though some previous studies have analyzed the characteristics of travel activity patterns, those studies generally paid attention to the overall situation in the whole city areas. None of previous studies have paid attention to the travel activity pattern in the historic urban area of a city. The travel behaviors and activity patterns within the historic urban area of a city are expected to be quite different from the overall situations in the city. For example, due to the concentrated land use pattern, the trip distance within the historic area is quite short as compared to that in the overall city area. Besides, the facilities of streets as well as attributes of trip modes are also very different from those of the overall city area. As a consequence, the findings from the overall cities in previous studies cannot accurately reflect the features of travel activity patterns in the historic urban areas. A study particularly focuses on the historic urban area which is important to help understand the unique characteristics of travel activities in the area. In addition, the study results that particularly focus on travel behaviors in historic urban areas can provide useful suggestion for the policy makings or city planning in the historic urban areas.

The primary objective of this study is to analyze the choice of residents' travel activity pattern in historic urban areas. Based on the survey data conducted in the historic urban area of Yangzhou, the travel activities of local residents in a whole day were classified into five types of patterns. The individual and household characteristics significantly related to the choice of activity patterns were investigated using the multinomial logit modeling (MNL) technique. The findings from historic urban areas were then compared to previous studies. The remainder of this study is organized as follows. The next section introduces the data resource. Section 3 introduces the methods used for modeling. Section 4 gives the data analysis results and discusses the findings. This paper ends with brief conclusions in Section 5.

2. Data

2.1. Study Area. The historic urban area in the city of Yangzhou was considered in this study to conduct the relevant analysis on the travel activity pattern. The description of the urban area of Yangzhou are shown in Figure 1. The historic urban area of Yangzhou is surrounded by the ancient canal, moat, and internal moat which covers about 5.09 square kilometers. The historic urban area is located in the central part of Yangzhou and is the commercial, financial, cultural, and medical center of the city. The city area of Yangzhou

Figure 2: The corridor schematic of historic urban area of Yangzhou.

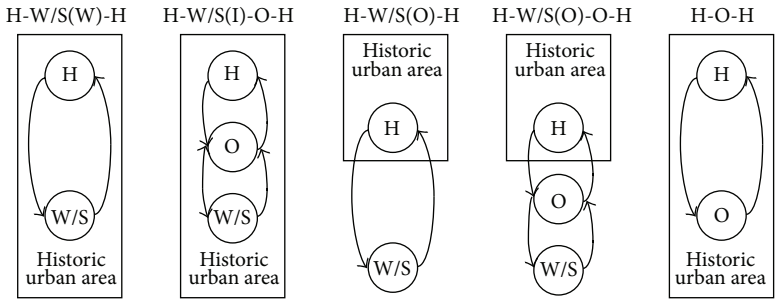


Figure 3: Illustrations of five types of travel activity patterns.

contains several subgroups with a distribution of a belt from east to west, as shown in Figure 2. The historic urban area is located in the middle of the belt. Because OF the city structure, the traffic from east to west and west to east all travels through the historic urban area. As a result, the historic urban area has quite a large amount of traffic which makes the area become congested.

The population of the historic urban area of Yangzhou in year 2012 is about one hundred thousand. The distribution of age of residents in this area presents a pattern of dumbbell: most middle-aged people with higher economic status have moved out of the historic urban area to the new developed area of the city, and the majority of people who currently live in the historic urban area are retired or self-employed with low income. Besides, there are many elementary and middle schools in the historic urban area which makes this area have a large number of young travelers. On average, the population density in the historic urban area is much higher than the other parts of Yangzhou. The travel activities in the historic urban area are expected to be different from the other areas, which are discussed in later sections.

2.2. Data Resource. Data used for analysis were obtained from the household survey in the city of Yangzhou, China, in year 2010. The household survey was conducted by the local government in one typical weekday to draw up the planning for transportation system in the city. The survey included two parts: (1) individual and household characteristics and (2) travel information of all trips in the whole day. A total of 2,000 questionnaires were assigned randomly to residents in the historic urban area. Questionnaires were distributed and collected by the neighborhood committees. Initially, 1,528 questionnaires were obtained. Samples with the following issues were excluded from further analysis: (1) cases of missing key information (such as trip mode or trip purpose) and (2) cases that have logic problems in the encoding process. Totally, 1,221 samples were obtained after the data selection.

In this study, a travel activity pattern (or trip chain) is defined as a sequence of trips that starts and ends at the home location in a whole day. According to previous studies, an activity pattern can be classified into different types by the complexity of activities (i.e., single and complex patterns) or trip purpose (i.e., subsistence and nonsubsistence patterns). In this study, the information of travel activity pattern was extracted from the household survey data in Yangzhou. Activity types that have small sample sizes (less than 1%) were excluded from analysis to avoid inaccurate estimates. Since this study focuses on the historic urban area in a city, the classification of activities is different from previous ones.

Finally, five major types of travel activity pattern were used for analysis, which are home-work/school (in historic urban area)-home (H-W/S(I)-H), home-work/school (in historic urban area)-other-home (H-W/S(I)-O-H), home-work/school (outside historic urban area)-home (H-W/S(O)-H), home-work/school (outside historic urban area)-other-home (H-W/S(O)-O-H), and home-other-home (H-O(I)-H). The illustrations of these activity patterns are shown in Figure 3. The descriptions of these five activity patterns are given as follows, where "h" denotes home, "w" denotes work, "s" denotes school, and "o" refers to other activities (nonsubsistence activities).

H-W/S(I)-H: there is one subsistence activity within a day. This activity pattern contains only a simple commuting activity stop. All the home and commuting stops are within the historic urban area.

H-W/S(I)-O-H: there are two types of activities within a day. This activity pattern is a combination of a simple commuting chain with a noncommuting activity stop. All the home and activity stops are within the historic urban area.

H-W/S(O)-H: there is one subsistence activity within a day. This activity pattern contains only a simple commuting activity stop. The home is located within the historic urban

area but the work/school is located outside the historic urban area.

H-W/S(O)-O-H: there are two types of activities within a day. This activity pattern is a combination of a simple commuting chain with a noncommuting activity stop. The home is located within the historic urban area, but at least one of the activity stops are outside the historic urban area.

H-O(I)-H: there is only one nonsubsistence activity within a day. This chain contains only a simple noncommuting activity stop. All the home and intermediate stop are within the historic urban area.

3. Methodology

In this study, we would like to estimate the impacts of explanatory variables on the choice of activity patterns in the historic urban area. The dependent variable includes five categories which are the five types of activity patterns. Thus, the MNL model which is based on the logistic distribution for disordered category variables is used for the data analysis. The MNL model has been widely used by researchers for the analysis of choices of trip modes and activities [26–28]. The methodology of MNL model was briefly introduced in this section.

On the basis of the random utility theory, the unity of n selects the activity pattern of i which can be expressed as

$$U_{in} = V_{in} + \varepsilon_{in}, \tag{1}$$

where U_{in} is the utility sample n for activity pattern i, V_{in} is called the systematic components of utility, and ε_{in} is the random parts.

When it is a linear relationship between V_{in} and the explanatory variables, it contains V_{in} which can be express as

$$V_{in} = \theta' X_{in} = \sum_{k=1}^{K} \theta_k x_{ink}, \tag{2}$$

where K is the number of explanatory variables; θ_k is coefficient to be estimated; x_{ink} is an explanatory variable.

Assuming that the random terms of the utility function subject to the double exponential distribution, the probability that the activity pattern i selected by the individual n is

$$P_{in} = \frac{\exp V_{in}}{\sum_{j \in A_n} \exp V_{jn}} = \frac{\exp\left(\sum_{k=1}^{K} \theta_k x_{ink}\right)}{\sum_{j \in A_n} \exp\left(\sum_{k=1}^{K} \theta_k x_{ink}\right)}. \tag{3}$$

For estimation of the parameter vectors $\boldsymbol{\theta}$ by maximum likelihood, the log likelihood function is shown as follows:

$$\mathrm{LL} = \sum_{n=1}^{N} \left(\sum_{k=1}^{K} \delta_{ik} \left[\theta_k X_{kn} - LN \sum_{\forall k} \mathrm{EXP}\left(\theta_k X_{kn}\right) \right] \right). \tag{4}$$

Since the estimation process of maximum likelihood is not the major objective of this study, the details of the estimation process are not given here. Interested readers could refer to Washington et al. [28] for more details on the estimation of MNL models.

Table 1: Trip characteristics between Yangzhou and its historic urban area.

Categories	Yangzhou	Historic urban area
Average daily travel times	2.81 times/day	2.99 times/day
Trip mode		
Walk	16.4%	27.4%
Electric bicycle/bicycle	53.9%	50.3%
Car	5.5%	3%
Public transit	6.3%	8.5%
Motorcycle	15.5%	9.9%
Other	2.4%	0.9%
Age		
<50 years old	70.8%	61.4%
>50 years old	29.2%	38.6%
Occupation		
Retiree	16.5%	25.4%
student/staff/service	58.0%	49.9%
Private	25.5%	24.7%
Trip purpose		
School	24.7%	19.3%
Work	6.8%	6.3%
Home	47.1%	47.3%
Other	21.4%	27.1%

4. Results and Discussion

4.1. Preliminary Analysis. In the first section we have discussed that the travel behaviors in the historic urban area of a city are expected to be quite different from the overall situations. In this section, the preliminary analysis was first conducted to compare the basic characteristics of travels between the historic urban area and the overall city. The results are shown in Table 1. The contents in Table 1 suggest that an analysis of travel activity pattern particularly on the historic urban area is necessary.

It is found that the travel behaviors are quite different between the two area scopes: (1) the average daily travel time in historic urban area (2.99 times/day) is more than that of overall area in Yangzhou (2.81 times/day). (2) The percentage of age above 50 in historic urban area (38.6%) is higher than the overall city area of Yangzhou (29.2%), and the occupations in historic urban area are also different from the overall area. (3) The percentage of walk mode in historic urban area (27.4%) is significantly higher than in the overall area of Yangzhou (16.4%), which could be because the trip distance within the historic urban area is shorter. (4) There are more public transit travels and less bicycle, car, and motorcycle in the historic urban area. (5) The trips to work/school in historic urban area are a little lower than overall area, and the trips to home in historic urban area higher.

Table 2 reports the statistics of activity patterns by type in the sample. The activity patterns "H-W/S(I)-H" and "H-O(I)-H" are the most common patterns that present 41.3 and 33.9 of all activities, respectively, which is comparable to

Table 2: Statistics of five types of travel activity patterns.

Activity pattern	Frequency	Percentage
H-W/S(I)-H	505	41.3
H-W/S(I)-O-H	183	15
H-W/S(O)-H	96	7.9
H-W/S(O)-O-H	23	1.9
H-O(I)-H	414	33.9
Total	1221	100

some previous studies [18, 23, 25]. The activity pattern "H-W/S(O)-O-H" occupies the least market which is only 1.9%. The information in Table 2 suggests that most of the activities were made within the historic urban area.

In the preliminary analysis we also compared the proportion of trip modes for the five types of activity patterns. The results are shown in Table 3. It is found that bicycle (including electric bike and conventional bike) is the nominate trip mode in the commuting activities (which are H-W/S(I)-H, H-W/S(I)-O-H, and H-W/S(O)-H) with the percentages over 50%. In the two nonsubsistence activity patterns (which are H-W/S(O)-O-H, and H-O(I)-H) bicycle usages are much lower. Public transit occupies a low mode share in all the activity patterns. Car is most commonly used for nonsubsistence travels outside the historic urban area. Besides, motorcycle accounts for a relative large number of travels in most of activity patterns. The information in Table 3 suggests that the mode share is different between activity patterns in the historic urban area of Yangzhou.

Our research team also investigated several personal attributes in the five types of travel activity patterns in the historic urban area. The results are shown in Figure 4. It is found in Figure 4(a) that there are more male travelers in the subsistence activity patterns H-W/S(I)-H and H-W/S(O)-H, and less males in the nonsubsistence patterns including H-W/S(I)-O-H, H-W/S(O)-O-H, and H-O(I)-H. The reason could be that females are more likely to have shopping or other maintenance travels than males. Figure 4(b) suggests that people older than 50 are more likely to have nonsubsistence activities. The percentage of population over 50 years old in activity pattern H-O(I)-H is much higher than the other patterns. The information of Figure 4 suggests that the personal (and household) characteristics have significant impacts on the choice of travel activity patterns, which are discussed in detail in the following section.

4.2. Modeling Results. The choice of travel activity pattern is impacted by the personal and household characteristics. In the household survey of this study, personal attributes include gender, occupation, and age. While household population, preschoolers, private cars, the number of bikes and electronic bikes, motorcycle, and incomes constitute household attributes. Affected by those factors, residents plan their daily activities and adopt appropriate activity patterns. The statistics of explanatory variables used for model development are shown in Table 4.

The MNL model was developed in this section to identify the impacts of explanatory variables listed in Table 4 on the choice of activity pattern. Initially, all explanatory variables were considered in the models. Variables not significantly related to the outcome were excluded from the model specification step by step. The contributing factors were kept in the model specification. The variable selection processes were repeated to carefully determine the contributing factors in the final model. The multinomial logistic module of statistical software SPSS was used to calibrate the parameters of each available in the MNL model. The estimation results of the MNL model shown in Table 5.

In the MNL model, the activity pattern H-O(I)-H is specified as the reference category. All the parameter estimates in Table 5 reflect the impacts of each variable on the changes of probabilities of the activity patterns with respect to the probability of pattern H-O(I)-H. The model estimates are interpreted as follows.

Gender is estimated to have significant effects on the probabilities of H-W/S(I)-H, H-W/S(I)-O-H and H-W/S(O)-H, activity patterns. The coefficient of gender for the H-W/S(W)-H and H-W/S(O)-H patterns is 0.76 and 0.891, and for the H-W/S(W)-H pattern is −0.559. It suggests that male travelers prefer to choose the activity pattern of H-W/S(I)-W and H-W/S(O)-H, of which the probabilities are 2.138 and 2.437 times more than female travelers. The reason for this phenomenon is that females could be more likely to make shopping and other types of travels for maintenance and recreations. Thus females are more likely to make H-W/S(I)-H activity pattern between work and home.

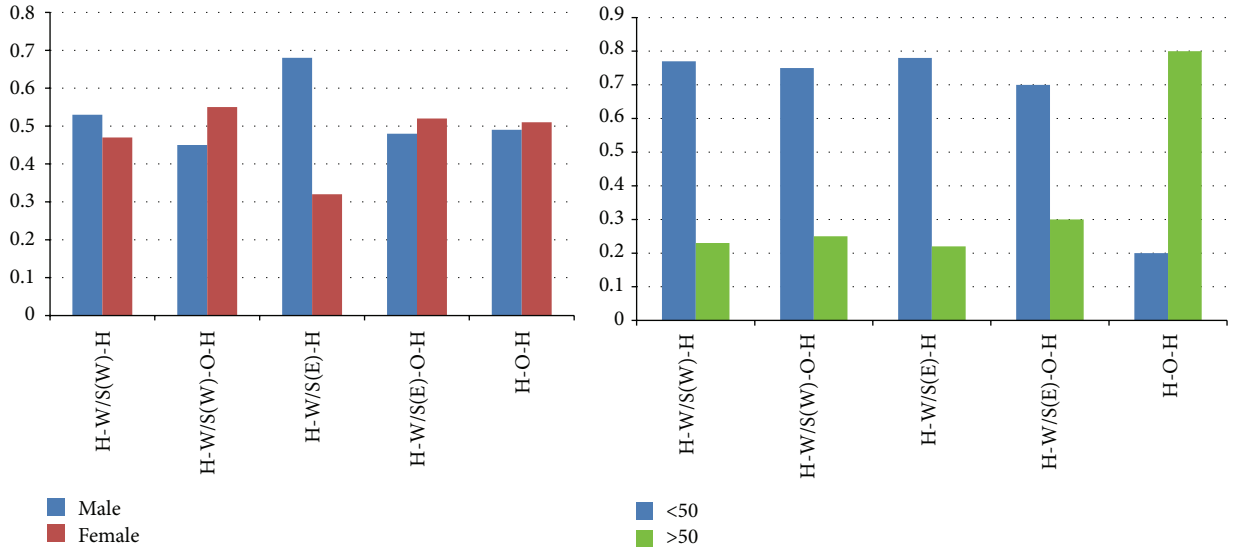
The occupation variable (OCC = 1) estimated in the H-W/S(I)-H, H-W/S(I)-O-H, and H-W/S(O)-H activity patterns is negative, and OCC = 2 are all positive in the four activity patterns. The reasons for the results could be that students/staff/service participate in work/school while retirees have little such trip purposes which coincides with the real situation. The coefficients of age variable (AGE = 1 and AGE = 2) for H-W/S(I)-H, H-W/S(I)-O-H, and H-W/S(O)-H activity patterns estimated in the model are all positive. It could be because the residents younger than 50 are mainly staff and students, which could have more commuting activities than these older than 50.

Several household attributes such as car ownership and number of electric bicycles are found to have significant impacts on the probability of H-W/S(O)-H activity pattern. The coefficient of car ownership and number of electric bicycles is −2.064 and −2.177, indicating that travelers that do not have a car or electric bicycles is less likely to choose the activity pattern H-W/S(O)-O-H. The reason could be that car and electric bicycle have relative high speeds and are quite convenient to use. Without a car or electric bicycle travelers that do not make activities with multiple purposes outside the historic urban area. Some variables including the income, household population, preschoolers, and number of conventional bicycles and motorcycles are not found to have obvious impact on the choice of travel activity pattern in the historic urban area.

The modeling results of choice of activity pattern from the historic urban area are compared to the findings from

Table 3: The proportion of trip modes for the five types of activity patterns.

Activity pattern	Walk (%)	Bicycle (%)	Car (%)	Public transit (%)	Motorcycle (%)
H-W/S(W)-H	5.3	65.6	4.4	6.1	18.6
H-W/S(W)-O-H	10.5	50.9	6.7	7.4	24.5
H-W/S(O)-H	0	58.6	4.0	8.1	29.3
H-W/S(O)-O-H	13.0	34.8	26.1	4.3	21.8
H-O(I)-H	35.2	39.7	9.1	10.7	5.3



(a) Gender information in each activity pattern

(b) Age information in each activity pattern

Figure 4: Personal attributes in the five activity patterns in historic urban area.

previous studies which focus on the overall city areas. Several consistent findings are obtained for the two study scopes. For example, both this study and previous ones report that the individual characteristics including age, gender, and occupation are significantly related to the choice of activity pattern. For example, the studies conducted by Allaman et al. [34], Lu and Pas [35], and Kuppam and Pendyala [36] all showed that the personal attributes such as gender, age, and occupation significantly affected travelers' activities. The findings from our study further confirmed the results of previous studies.

There are some inconsistent findings between our study and previous ones. For the historic urban areas as found in this study, only two household characteristics variables were found to be significantly related to activity choices. The other household related variables were not found to be contributing factors which was different as compared to previous findings for the overall city areas. For example, Kuppam and Pendyala [36] and Lu and Pas [35] found that the household income, number of bicycles in household, and number of family members were found to be contributing factors which were not found in this study. The number of children in household was found to be an important factors in the study by Golob [37] and Lu and Pas [35]. The reason for the difference of findings could be that in the historical areas, the choice of activity pattern is restricted by the characteristics of historical areas such as limited road resource and large traffic demands. In our case of Yangzhou in 2012, the road length per capita in the overall city is 8.84 m and the road area per capita is 13.94 m^2, while the two measures in the historic area are 13.26 m and 19.45 m^2, respectively. And the average daily travel times in the overall city is 2.81 times/day, while in the historic area is 2.99 times/day. Thus, travelers with different household characteristics have to make similar activity choices, making the impacts of household factors on travel activities less significant.

The possible reason for the different findings could be that in the historic urban area most of the people have relative low income level which makes the variable of income not significant. Another reason could be that due to the limited road resource and high activity frequency the people that have higher income level do not have more selections on the travels. In historic areas the width of streets is much lower than the other places in the city area, and the buses usually run slow due to the congested traffic in historic areas. Thus, these reasons lead to the results that the number of bicycles in household is not significantly related to activity choice. Household population is not significant, probably because there are many retirees in historic urban area of Yangzhou (the proportion of people over 50 years old is 29.2% for

Table 4: Statistics of explanatory variables for model development.

Attributes	Variable	Definition	Frequency (%)
Personal attributes	Gender (GEN)	Male (=1)	653 (53.5%)
		Female (=0)	568 (46.5%)
	Occupation (OCC)	Retiree (=1)	273 (22.4%)
		Student/staff/service (=2)	599 (49.1%)
		Private (=0)	349 (28.6%)
	Age (AGE)	<30 (=1)	579 (47.4%)
		30–49 (=2)	118 (9.7%)
		>50 (=0)	524 (42.9%)
Household attributes	Household population (HP)	<3 (=1)	397 (32.5%)
		More than 3 (=0)	824 (67.5%)
	Preschoolers (CH)	Have (=1)	200 (16.4%)
		Without (=0)	1021 (83.6%)
	Car ownership (CAR)	Have (=1)	68 (5.6%)
		Without (=0)	1153 (94.4%)
	Number of conventional bicycle (BIC)	0 (=0)	254 (20.8%)
		1-2 (=1)	855 (70%)
		>3 (=2)	112 (9.2%)
	Number of electric bicycle (EBIC)	0 (=0)	498 (40.8%)
		1-2 (=1)	698 (57.2%)
		>3 (=2)	25 (2%)
	Motorcycle ownership (MOT)	Have (=1)	477 (39.1%)
		Without (=0)	744 (60.9%)
	Income (INC)	<¥ 10000 (=1)	190 (15.6%)
		¥ 10000–50000 (=2)	900 (73.7%)
		>¥ 50000 (=0)	131 (10.7%)

Table 5: Estimation results of the MNL model.

	H-W/S(I)-H[a]		H-W/S(I)-O-H		H-W/S(O)-H		H-W/S(O)-O-H	
	Coeff.	Sig.	Coeff.	Sig.	Coeff.	Sig.	Coeff.	Sig.
Intercept	−2.329	0.002	−1.969	0.002	−3.469	0.002	−5.493	0.002
[GEN = 1]	0.76	0.001	−0.559	0.027	0.891	0.007		
[OCC = 1]	−2.604	<0.001	−1.443	<0.001	−2.076	0.008		
[OCC = 2]	2.297	<0.001	2.191	<0.001	2.687	<0.001	1.624	0.001
[AGE = 1]	1.521	<0.001	1.091	0.024	1.51	0.005		
[AGE = 2]	1.143	<0.001	1.297	<0.001	1.421	<0.001		
[HP = 1]	[b]							
[CH = 1]								
[CAR = 1]							2.064	0.001
[BIC = 1]								
[BIC = 2]								
[EBIC = 1]							2.177	0.040
[EBIC = 2]								
[MOT = 1]								
[INC = 1]								
[INC = 2]								

[a]The reference category of activity pattern is H-O(I)-H.

[b]Estimates of variables not significant at a 90% confidence level are not given.

the overall city area and 38.6% for the historic urban area), and they have done shopping and other travel behaviors during their travels. The families with preschoolers are always taken care of by the retirees, so the impact of preschoolers on travel activity pattern is not significant either.

5. Conclusions

This study analyzed the characteristics of residents' travel activity patterns in historic urban area of a city and evaluated the impacts of explanatory variables on the choice of activity pattern. The data used for analysis in this study were obtained from the household survey in the historic urban area of Yangzhou. Based on the data, the travel activities of local residents in a whole day were classified into five types of patterns which were the (H-W/S(I)-H), home-work/school (in historic urban area)-other-home (H-W/S(I)-O-H), home-work/school (outside historic urban area)-home (H-W/S(O)-H), home-work/school (outside historic urban area)-other-home (H-W/S(O)-O-H), and home-other-home (H-O(I)-H). The multinomial logit (MNL) model was developed in this study to evaluate the impacts of explanatory variables on the choices of activity patterns. The findings of this study were compared to previous ones.

Based on the data analysis results, the following conclusions were obtained.

(1) Bicycle is the dominate mode of transport in historic urban area for the subsistence or commuting activity patterns H-W/S(I)-H, H-W/S(I)-O-H, and H-W/S(O)-H. Car is most commonly used for activity patterns H-W/S(O)-O-H which contains trips outside the historic urban area. Public transit is most commonly used in the single noncommuting activity pattern H-O(I)-H. The overall mode share of public transit is quite small, indicating that improving the level of service of public transit will help reduce the pressure of traffic in historic urban area.

(2) Male travelers prefer to select the activity pattern H-W/S(W)-H and H-W/S(O)-H, and female are prone to choose the H-W/S(W)-O-H pattern. The households without car and electric bicycle seldom select the H-W/S(O)-O-H pattern. The residents who are younger than 50 and students/staff/services are more likely to choose the H-W/S(I)-H, H-W/S(I)-O-H, and H-W/S(O)-H patterns.

(3) Among family attributes, ownership of private car and the number of electronic bicycles have significant effect on the choice of activity pattern. The other variables, which were the family population, preschoolers, number of conventional bike in household, motorcycle ownership, and income, were found to be not significantly related to the choice of activities.

Findings of this study on the travel activity patterns in historic urban areas could help transportation planners better understand the characteristics of travels and develop strategies to reduce the congestion in such areas. This study provides important suggestions for the policy makings to improve the traffic situations in historic urban areas of cities. However, due to the limitations of the survey data, we just get the relationship between historic urban area resident activity pattern and personal and family attributes. We did not consider the trip mode selection during the analysis on travel activity pattern choice. In our future studies, we would like to analyze the choices of trip modes and activity patterns simultaneously and consider the correlations between the two choices. Besides, many travelers in historic urban area are tourists other than local residents. It is interesting to compare the characteristics of travel activities between tourists and residents. Future studies may focus on the above topics.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

Acknowledgments

This research is supported by the Projects of the National Natural Science Foundation of China (no. 51208256 and no. 51178157). The authors would like to thank the senior students from Department of Transportation Engineering of Nanjing University of Science and Technology for their assistance in data collection and reduction. Especially, the authors thank Dr. Chen Yang and Dr. Zhibin Li in Southeast University for offering to help in this research.

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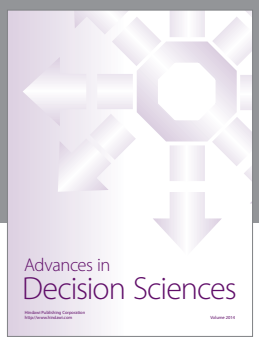

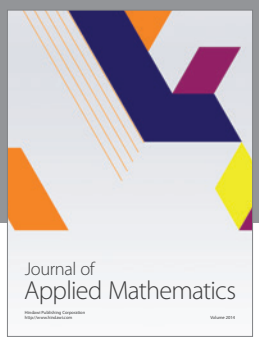

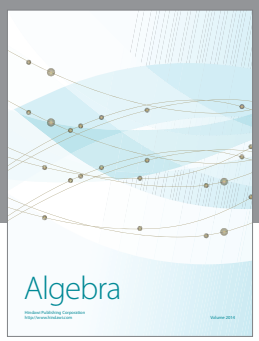

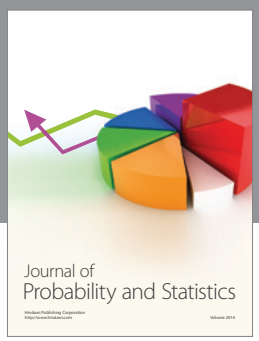

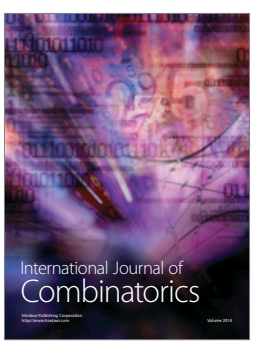

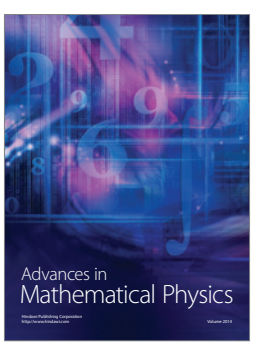

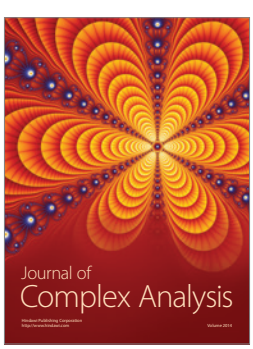

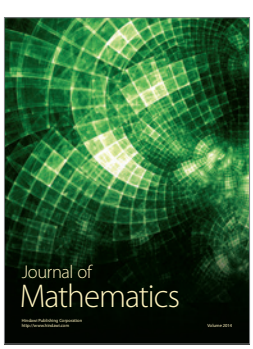

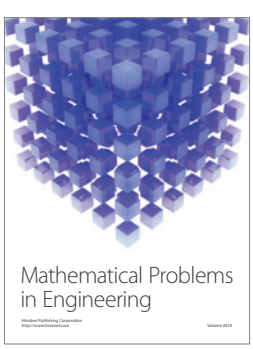

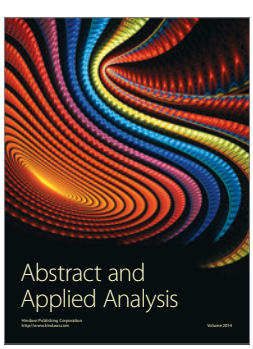

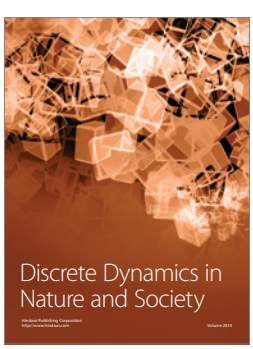

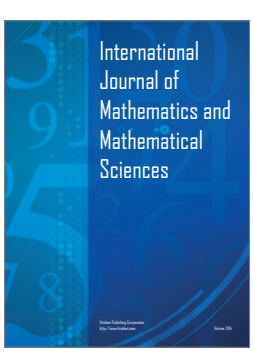

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