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The Key Contributing Factors of Customized Shuttle Bus in Rush Hour: a Case Study in Harbin City

Yang Cao, Jian Wang*

School of Transportation Science and Engineering, Harbin Institute of Technology, Harbin 150090, China

Abstract

Recently, the policy to reduce private car sharing and switch the private car users to public transportation has gained much attention. Research has shown the accordance that developing public transportation to promote sustainable transportation. However, sometimes the subway and bus transit with high congestion level do not match the comfortable degree of demand, and the transit with fixed routes cannot satisfy the flexibility of transport. Hence, the customized shuttle bus becomes a new way of public transportation. Most studies on the implementation and application of customized shuttle bus are only for large cities. However, limited studies have been conducted on the key contributing factors of customized shuttle bus in medium city. In this paper, Harbin City, the capital city of Heilongjiang Province, is selected as the case study. The contingent valuable method is employed and 332 individuals complete in the SP (Stated Preference) and RP (Revealed Preference) survey to measure the individual willingness to choose customized shuttle bus. Key contributing factors that are expected to influence customized shuttle bus are analyzed by logistic regressions. The results show that there are four key contributing factors that influence people to choose customized shuttle bus, which are private car, distance between home and work place, travel satisfaction level and work overtime. Finally, some suitable proposals for the implementation of customized shuttle bus are proposed, which are helpful to make public transportation policy in Harbin and other developing cities.

* Corresponding author. Tel.: +86-15246661633; fax: +86-0451-86282616.
  E-mail address: wang_jian@hit.edu.cn

1. Introduction

The service of customized shuttle bus can reduce the automobiles' usage, which could be benefit for alleviating traffic congestion in rush-hour on workdays, supplying green transportation mode for traveler and improving the urban air quality. Urban traffic congestion is one of the bottlenecks that restrict development of economic. The key reason of congestion is that the growth rate of motor vehicle is higher than urban transportation's infrastructure construction. A lot of people are now highly dependent on car traveling, particularly on workdays, due to private car can give free time, security, comfortable travel and avoid in-vehicle crowd on the bus or in the subway. However the longer time of congestion on the road, the higher of travel cost will be. The cost includes congestion pricing, parking charging and fuel taxes [1], which would reduce the attractiveness of car use [2]. The traveler should think carefully to choose public transport or private car. Public transportation such as bus, light rail and subway, plays an important role in urban transportation. Nevertheless, private car users pay little attention on public transportation, because the latter cannot provide satisfied service. Recently, a new transport mode named customized shuttle bus is being constructed in several cities in China [3], for instance Beijing, Qingdao, Shenzhen, Chengdu. Customized shuttle bus is a traffic mode between bus and taxis, according to the demand of travelers to determine the routes and stops between large-scale community and workspaces. It is equipped with air condition, wireless network, TV, water and other services.

Customized shuttle bus is similar with the travel mode of Demand Responsive Transport (DRT) [4] and Flexible Transport Service (FTS) [5], which were appeared in European and American cities between suburbs and downtown in the 1970s, then with the development of the suburbs urbanized and the increase of passenger flow, the DRT and FTS routes gradually become transit routes. Brake et al. [6] paid more attention to DRT and analyzed the provision in rural areas of British. Davison et al. [7, 8] conducted the survey in Britain and identified the potential market of DRT. Finn [9] introduced the successes and failures experience of FTS in several cities from practical perspective. Mulley et al. [10, 11] studied the demand of FTS and compared experiences and problem in FTS system on different district. Velaga et al. [12] used argumentation theory to present an agent-based FTS system platform in rural region. Furthermore, more application is in the airport and school, many issues such as shuttle buses in airport and school bus [13] were studied by the researchers. Particular, the rout design [14] and modeling have been discussed in a small number of papers.

As discussed above, although different mode of shuttle bus was studied for special people in urban or rural areas, the system that is composed of DRT and FTS and customized shuttle bus is a good supplement for changing car users' travel behavior from private car to public transport. However, few studies pay attention to demand of customized shuttle bus in developing cities. Travel demand varies as economic level. Especially the key contributing factors of customized shuttle bus in the developing world play important roles in carrying out customized shuttle bus.

Compared with traditional public transit services, previous researches of shuttle bus has neglected the comfortable personalization on the bus service, such as one passenger one seat from community to work units. Thus, these previous results are unsatisfactory in developing cities, where the travel demand is increasing quickly. We aim to provide more documents to explain the demand of customized shuttle bus, and evaluate the key contributing factors of customized shuttle bus in developing cities. Attention is put on customized shuttle bus in developing cites with over 3 million inhabitants. The Harbin City in the northeast of China is chosen for the analysis. One of the major reasons for choosing this city as case study is that: (i) there is different travel demand in Harbin City comparing with the large metropolitan city (such as Beijing) from population scale, the level of economic development; (ii) the number of medium cities in the world is larger than that of large metropolitan cities; (iii) the failure of customized shuttle bus in Harbin. The government chooses two most busy bus routes as pilot of customized shuttle bus in Harbin, but the experiment is not successful. The reason for the failure is that there is no systematic analysis of customized shuttle bus and the most important contributing factors to customized shuttle bus are not clear. Therefore, the study of key contributing factors is urgently needed at present, which is useful to the development of this special travel mode. In addition, further research about future development of customized shuttle bus is discussed. Eventually, as one mode of public transportation, the customized shuttle bus is useful to reduce private car use on workdays, which can provide clues to public transport management in the process of optimizing the structure of traffic mode.

In the next section "Investigation design and methods", the urban transportation of Harbin is introduced and the demand of customized shuttle bus is discussed by surveys, then the research method of logistic regression is introduced. The results and discussion of customized shuttle bus is analyzed in Section 3. In the last section, the conclusions are summarized and the future research is discussed.

2. Investigation design and methods

2.1. Urban transportation in Harbin City

Harbin is capital of Heilongjiang province of China, which is the political, economic and cultural center of northeast of China. At the end of 2013 years, city population is 4.714 million, the number of public transit vehicle is 5433, the length of bus road is 776.6km, the bus encoding is 205 lines, bus mileage every day is 1.08 million km, the number of taxi is 15519, car ownership is 0.808 million. The 146 new roads, 34 new bridges and 0.0345 million parking space was built. Harbin No.1 subway line has been opened, No.2 and No.3 subway are under construction. These data come from the Harbin Statistic Bureau.

As a lot of cities, Harbin is also experiencing traffic congestion in rush hours. The reason could be more and more families own their car with the economic development quickly. However, the speed rate of road construction is lower than the vehicle increasing rate. Although public transit has been improved, the bus vehicle is still crowd in rush hour. To release the congestion, one hand, increase the construction of public transit, such as constructing Bus Rapid Transit and subway and applying the technology of Intelligent Transportation System. The other hand, encourage private car user to choose public transit modes and promote variety of travel modes so as to reduce private car in rush hour. Customized shuttle bus is one of good way to replace private car, the cost lower than taxi and private car and the comfort higher bus and subway.

2.2. Investigation Design and Administration

This paper adopted the SP (Stated Preference) and RP (Revealed Preference) survey with questionnaire investigation to collect data, and then the actual travel behavior of residents and the willingness of customized shuttle bus were investigated. The quality of the questionnaire survey was guaranteed that we invited experts and the residents in a small scale survey. According to feedback of the survey, we increased the current concept of customized shuttle bus and the range of options, finally completed the design of the questionnaire. The questionnaires were distributed in the community and Central Business District and online on May to December 2014. Finally, 356 questionnaires were received and availability of questionnaire was audited. 332 questionnaires were effective with 93.3% by effective recovery rate.

Questionnaire mainly includes two parts of content, one is the actual travel information, and the other is willingness of customized shuttle bus. First part includes gender, age, job, the distance between the community and work unit, travel mode, one-way cost of time, transportation expenses, family private vehicle ownership situation, the cause of the travel choice of private cars, the evaluation of bus service, taxi service, subway service, etc. The second part is the intention survey of customized shuttle bus that includes the cognition, the willingness of selection, the ticket price, the simulation of customized shuttle bus, the comparison with private car, etc.

2.3. The Method of Logistic regression

The method of Logistic Regression was employed in the survey that the willingness to choose of customized shuttle bus in the developing city of Harbin. The model of Logistic Regression introduced by Menard and William [15] is applied in several disciplines. The advantage of logistic regression is a kind of curve model of classification variable and multiple factors. Hypothesis dependent variable Y is a binary classification variables. In this study if Y = 1 that means the willingness to choose of customized shuttle bus, if Y = 0 that means the unwillingness to choose of customized shuttle bus, there are m independent variable for instance $X_1, X_2, X_3...X_m$, as $P = P(Y = 1 \mid X_1, X_2, X_3...X_m)$ that indicate the probability under the m independent variables. The model of logistic regression can be expressed by

$$P = 1/\left[1 + \exp\left(-\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 \cdots + \beta_m X_m\right)\right] \tag{1}$$

Where β_0 is constant and β_1, β_2, $\beta_3 \ldots \beta_m$ is the regression coefficient. If $Z = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 \ldots + \beta_m X_m$ that the logistic curve between Z and P is approximate a S-shaped curve, then logarithmic transformation for the above formula, logistic regression model can be expressed as a linear form as follows

$$In\left[P/(1-P)\right] = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 \cdots + \beta_m X_m \tag{2}$$

Where left formula $In[P/(1-P)]$ is natural logarithm of probability ratio for Y = 1 or Y = 0, that Logit P is termed. From the above formula, although the range of P value is [0, 1], the scope of logit P is (-∞, +∞), through this transformation that linear regression model can explain the relationship between the dependent variable with the independent variable is by Logit (P).

In the survey, the willingness to choose of customized shuttle bus as the dependent variable, then Y = 1 (means the willingness to choose customized shuttle bus) and Y = 0 (means the unwillingness to choose customized shuttle bus). Establish logistic regression model and the age, gender, income, occupation, travel distance for work, private cars, work overtime, travel satisfaction level and so on was chosen. The classification more than two variables should be quantize dummy variables, which is shown in Table 1, the forward method (LR) was employed for variables into the method. Before the regression, the constant of regression model was tested, table 2 presented the result of constant test of logistic regression model, and finally regression coefficient was 0.145. Wals value equal to 1.732 and P = 1.732 (< 0.05), which indicate constant no statistical significance.

Table 1. The result of dummy variables.

		Frequency	Parameters of the code				
			(1)	(2)	(3)	(4)	(5)
Job	1	26	1.000	0.000	0.000	0.000	0.000
	2	134	0.000	1.000	0.000	0.000	0.000
	3	66	0.000	0.000	1.000	0.000	0.000
	5	10	0.000	0.000	0.000	1.000	0.000
	7	68	0.000	0.000	0.000	0.000	1.000
	8	28	0.000	0.000	0.000	0.000	0.000

Table 2. Variables in the equation.

		B	S.E,	Wals	Df	Sig.	Exp (B)
Step0	constant	0.145	0.110	1.732	1	0.188	1.156

Table 3. Model summary.

Step	-2 Log likelihood	Cox & Snell R square	Nagelkerke R square
1	442.266a	0.31	0.48
2	435.648a	0.40	0.55
3	429.166b	0.48	0.64
4	422.481b	0.67	0.76

The result summary of the model is shown in Table 3. The step 1 of Nagelkerke R square is 0.48. With the increase of fitting, R will increase and maximum is 0.76 in step four, which shows the goodness of fit is the best at this time. Then the comprehensive test results of model coefficient is shown in Table 4. Step 1 with private cars, travel distance for work was added in step 2, then the satisfaction of Harbin traffic situation was increased. Final

step, the work overtime was join in the model. There is statistical significance in the model. In the end there were four variables including private car, travel distance for work, travel satisfaction level and work overtime were joint into the model.

Table 4. Comprehensive test of the model coefficients.

		Chi-square	Df	Sig.
	Step	16.248	1	0.000
Step 1	Block	16.248	1	0.000
	Model	16.248	1	0.000
	Step	6.618	1	0.010
Step 2	Block	22.865	2	0.000
	Model	22.865	2	0.000
	Step	6.482	1	0.011
Step 3	Block	29.347	3	0.000
	Model	29.347	3	0.000
	Step	6.685	1	0.010
Step4	Block	36.032	4	0.000
	Model	36.032	4	0.000

3. Results and Discussions

3.1. Date Analysis

On the basis of 332 copies of survey questionnaire, statistics results displayed that male accounted for 52.54% and female is accounted for 47.64% whose proportions is closed with residents distribution of gender proportions. The age proportions in 19-35 and 36-45 respectively is 70.62% and 23.73%, which shows constitute of city residents mainly in youth. In the groups of survey, family income per month 3000-8000 Yuan RMB is majority, accounted for 47.46%, the 8000-15000 and less than 3000 Yuan RMB accounted for 23.73% and 20.9% respectively, higher-income families is 8.3%. 52.54% of these survey families have no car and 36.72% have more than one. The sort of travel mode selection includes bus, car, unit commuter car, walking, subway, taxi, which shows most travel modes in Harbin. The travel mode of subway is lest, which illustrate actual urban transport situation because the subway is at the early stage of construction.

In the evaluation of urban public transportation, evaluation of subway, bus, and taxi service is more than 50% with unsatisfied, which illustrate that public transportation service level is necessary to be improved. At the same time, urban traffic peak congestion is serious in generally.

In the willingness investigation of customized shuttle bus, if ticket price of customized shuttle bus is reasonable and take the bus is accessible and immediate, the rate of strong willingness is 42.37%, and thinking to try is 51.41% that shown in Figure 1. If the mode of customized shuttle bus is meet your travel needs, cost less than private cars, the rate of strong willingness is 46.89%, and thinking to try is 48.02% that shown in Figure 2. The results explain why public transportation with comfort and convenient will attract traveler to choose. If the cost is less than private and comfortable is equal with private car, the willingness will be strong. Compared with above data, the rate of thinking to try is higher than strong willingness. It should take some preferential policy to attract the traveler with wait-and-see attitude, such as first month free [16] and discounts.

When the questionnaire respondent has private car, the reason that the travelers travel by car was investigated. The comfort and convenience, sending child to school, cold winter and hot summer rank top there reasons with 71.19%, 54.8%, 36.72% respectively that shown in Figure 3, which illustrate that if public transportation can provide the corresponding services equal with private car, the transfer travelers from private car to public

transportation would have a higher share. On the other question, whether you will choose customized shuttle bus for yourself and your child, there are 73.45% to choose, which prove the consistence with response of above question.
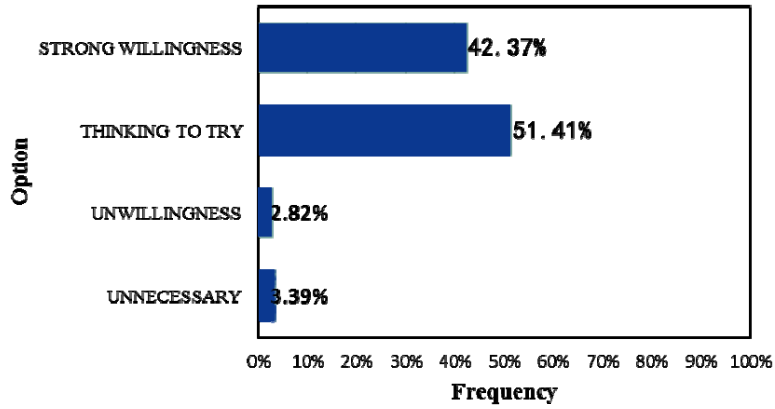

Fig. 1. The willingness of customized shuttle bus with question "if ticket price of customized shuttle bus is reasonable and take the bus is accessible and immediate".
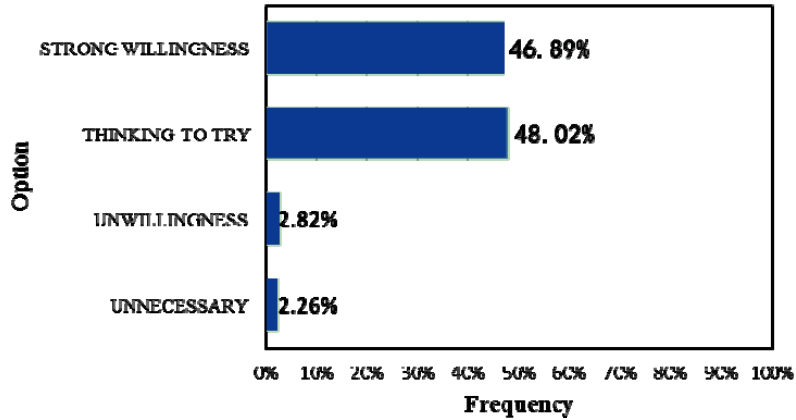

Fig. 2. The willingness of customized shuttle bus with question "the mode of customized shuttle bus is meet your travel needs, cost less than private cars".
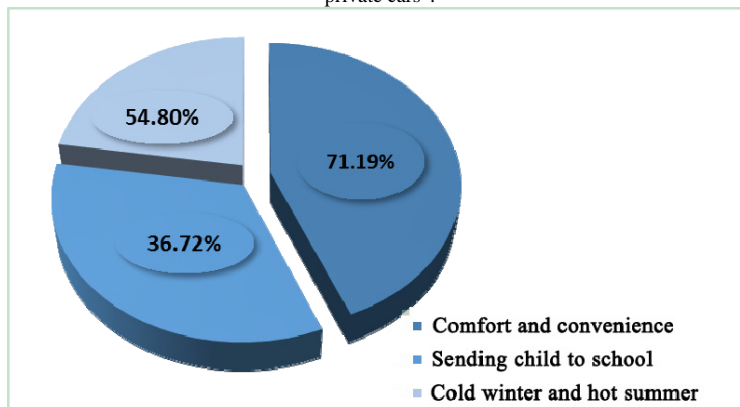

Fig. 3. The reason of the traveler travel by private car.

In summary, the questionnaires of customized shuttle bus indicate that the public transportation with comfort and convenience will satisfy the demand of travel, and customized shuttle bus is one of the effective patterns to meet personalized travel. At last the customized shuttle bus with multiplication will enhance customized shuttle bus to sustainable development, based on sufficient investigation and optimized design project.

3.2. The Result of Logistic Regression

All tables should be numbered with Arabic numerals. Every table should have a caption. Headings should be placed above tables, left justified. Only horizontal lines can be used within a table, to distinguish the column headings from the body of the table, and immediately above and below the table. Tables must be embedded into the text and not supplied separately. Below is an example which the authors may find useful.

The result of logistic regression is shown in Table 5. Four variables in the model for willingness of customized shuttle bus were proved to be statistical significance. It is observed that factors, for instant, private cars, travel distance for work, travel satisfaction level of Harbin and work overtime are conductive to customized shuttle bus in logistic regression model. The Logistic Regression Model of customized shuttle bus is shown as:

$$In\left[P/(1-P)\right] = -0.268 + 1.124X_1 + 0.386X_2 + 0.287X_3 - 0.361X_4 \tag{3}$$

Where X_1 is private car; X_2 is travel distance for work; X_3 is travel satisfaction level; X_4 is work overtime.

Table 5. The result of variables in the equation.

		B	S.E,	Wals	Df	Sig.	Exp (B)	EXP(B) 95% CI(upper limit)	EXP(B) 95% CI(lower limit)
	Private car	0.900	0.226	15.821	1	0.000	2.459	1.579	3.832
Step 1a	Constant	-0.281	0.154	3.327	1	0.068	0.755		
	Private car	0.920	0.229	16.134	1	0.000	2.509	1.602	3.930
Step 2b	Distance	0.237	0.094	6.347	1	0.012	1.268	1.054	1.525
	Constant	-0.753	0.244	9.531	1	0.002	0.471		
	Private car	0.985	0.233	17.786	1	0.000	2.677	1.694	4.230
	Distance	0.332	0.133	6.207	1	0.013	1.393	1.073	1.809
Step 3c	Satisfaction	0.267	0.096	7.778	1	0.005	1.306	1.083	1.575
	Constant	-1.341	0.342	15.341	1	0.000	0.262		
	Private car	1.124	0.244	21.184	1	0.000	3.078	1.907	4.968
Step 4d	Distance	0.386	0.135	8.120	1	0.004	1.471	1.128	1.918
	Satisfaction	0.287	0.097	8.727	1	0.003	1.332	1.101	1.611
	Work overtime	-0.361	0.143	6.359	1	0.012	0.697	0.526	0.923
	Constant	-0.268	0.545	0.243	1	0.622	0.765		

There are several factors affecting travelers to choose customized shuttle bus, such as age, career, the level of domestic consumption, travel habits, family, taking the child to school, weather, private car, travel distance for work, travel satisfaction level, work overtime, and so on. At the same time, the customized shuttle bus service, the ticket price, the number of group for departure time and site also affect travelers to choose customized shuttle bus or not. Based on the Logistic Regression Model of customized shuttle bus, we can get the key contributing factors to be private car, travel distance for work, travel satisfaction level, and work overtime, which should be mainly considered when making customized shuttle bus policy.

Specially, the percentage of who own private cars have more willingness to choose customized shuttle bus is 3.078 times of percentage who have not own private car. It indicates that the target group of customized shuttle bus is the car owner that accordance with the actual travel demands. Because the ticket price of customized shuttle bus is usually lower than taxi fee and car expense, it appeals car owner drop travel by car and choose customized shuttle bus. On the other hand, travelers without car usually have less income, thus little possibility for them to choose customized shuttle bus.

The possibility to choose customized shuttle bus with distance more than 8 kilometers is 1.471 times of the possibility to choose customized shuttle bus with distance less than 8 kilometers. It means that travelers who have longer distance between home and work will have more possibility to accept customized shuttle bus. The traveler with short travel distance can choose private car, taxi, subway or bus, and the fee is equal or less than that of customized shuttle bus, so the attraction of customized shuttle bus for short-distance traveler is less than long-distance traveler.

Furthermore, the evaluation of Harbin travel satisfaction level decreases one score, the possibility to choose customized shuttle bus will increase 1.332 times. The customized shuttle bus is the product for special travel demand under special period. It explains that the significance of public transportation convenience with travel choose of customized shuttle bus. In other word, when public traffic can supply better service to satisfy traveler, the customized shuttle bus will turn to decline after mature period.

Finally, the travelers with work overtime to accept the possibility of customized shuttle bus is 0.697 times of travelers without work overtime. The reason could be that travelers without work overtime have the stable commute time which increases the possibility to choose customized shuttle bus.

4. Conclusions

This paper introduced customized shuttle bus as the way to reduce car usage on workdays, by taking Harbin city as the case study. The analysis of the customized shuttle buses indicates that in order to reduce the private car use, the service should be designed in multiple ways to serve customers. Furthermore, customized shuttle bus is one part of mass public transportation. Based on logistic regression, we can see the key contributing factors of customized shuttle bus including private car, distance between home and work place, travel satisfaction level and work overtime. The result is useful for the city of different population scale. Based on this study, future research directions can been identified which will not only improve the attraction of green public transportation, but also advise transit agencies about what are useful transport policy.

Acknowledgements

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