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Children's School-Bound Traveling Behaviors and Strategies Under the Two-Child Policy

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Abstract: The two-child policy will result in a growing number of school-age children and the change of household structures, which makes urban residents' travel behaviors and family decisions more complicated. This paper analyzes the characteristics of future school-bound traveling behavior of children in two-child families based on RP and SP investigation. By adopting the structural modeling concept, the paper develops a school-bound traveling behavior model with families as decision-making units to study the commuting decision-making. The results show that parents' key decision making factors on picking-up and dropping-off of school-bound children are the age and safety awareness of the children, distance to school, road traffic safety conditions, and conveniences of public transit. Based on the investigation and modeling results, the paper proposes policies on urban planning, transportation system development, optimization of school-bound traveling and reduction on urban traffic demand. **DOI:** 10.13813/j.cn11-5141/u.2020.0007-en

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0 Introduction

With the implementation of the universal two-child policy, the total number of school-age children will grow significantly. At the same time, the changes in household structure will also vary the influencing factors and their interactions of household members' travel decisions. It can be predicted that the two-child policy will have a profound impact on the overall travel demand of the society. Travel demand is the basis of planning, construction and management regarding urban transportation, so the study of school-age children's school-bound traveling in the context of the two-child policy is necessary for the management of travel demands and related urban development strategies.

School-age children have diverse travel needs, and the research in this paper focuses on school-bound traveling. School-bound traveling refers to the trips made by school-age children that take their homes and schools as their origins and destinations. As the rigid demand of school-age children, it is relatively stable in time and space, which is concentrated in certain periods and areas. Because the time for school-bound traveling overlaps with the morning and evening peak hours and affects the commute trips of other household members, it imposes a significant impact on the load of the urban transportation system.

Early research on children's travel behavior was mostly based on descriptive statistics. In recent years, more attention has been paid to the study of travel behavior models. Related research can be generally divided into three categories from different perspectives: 1) Analysis based on survey statistics: Reference [1] found that households with more school-age children have a higher proportion to use school buses. 2) Study on the mode choice of school-bound traveling: Reference [2] studied the relationship between school location and school-age children's travel modes, and Reference [3] studied the differences when school-age children choose

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walking, public transit and cars for their school-bound traveling. 3) Research on the interaction of household members, which usually takes a household as the analysis unit and children as the influencing factor to study their constraints on the commute modes of household members: Reference [4] established a model of constraints on the commute modes of household members placed by school-age children, and Reference [5] proposed the concept of commuter constraint degree to investigate the influence of commuting activities of different households on the decision-making of school-bound traveling. The first category of research is strongly limited by the number of samples and the survey area [6–9]. The latter two categories build models based on travel behavior, which usually take each child as the analysis unit and mostly use the Multinomial Logit Model (MNL model) or Nominal Logit Model (NL model) to analyze the impact of a variable on the travel mode when other variables are unchanged. However, many factors could affect the school-bound traveling of school-age children, and they are complex and interact with each other, so it is difficult to identify the internal relationship among them [10–12].

Therefore, this paper intends to analyze the traveling characteristics of school-age children in two-child households based on Revealed Preference (RP) and Stated Preference (SP). According to the principle of structural equations, a model of school-bound traveling behavior with households as the decision-making units is established to study the internal mechanism of choices regarding school-bound traveling and quantify the influence of various factors on the school-bound traveling behavior of school-age children. Model results are referred to propose strategies for optimal management.

1 Survey and behavior analysis of school-age children's school-bound traveling

The universal two-child policy was officially implemented on January 1, 2016. In the long run, it will not only increase the overall number of school-age children but pose a significant impact on the school-bound traveling behavior of school-age children. However, due to the response lag of the policy, its impact on the household structure has not been fully reflected yet and the proportion of households with two school-age children is still small, so it is necessary to combine RP and SP for relevant analysis.

1.1 Data collection

School-age children can be divided by stages into elementary school students (6–12 years old), middle school students (12–15 years old) and high school students (15–18 years old). Children in middle and high schools already have partial ability to travel independently, and their travel characteristics are gradually approaching those of adults. In addition, it is less likely for a household with a middle or high school student to have two school-age children in the household in the future. Therefore, this paper selected the parents of elementary school students as the respondents and defined the survey scope as the central urban area of Beijing. It adopted the stratified random sampling to conduct the RP and SP at the same time and used both on-site paper questionnaires and online questionnaires. The surveys continued for three months (November 15, 2016–January 13, 2017), and a total of 420 questionnaires were collected. The consistency between the drop-off/pick-up decision and the trip mode was examined and invalid samples were eliminated, which led to 327 valid samples. The distribution of basic information of school-age children is shown in Table 1. It shows that the sample distribution is even and realistic, which meets the data requirements of structural equation modeling.

1.2 Analysis of school-bound traveling behavior

Statistical analysis was conducted on the survey data to analyze the school-bound traveling behavior of school-age children. The main conclusions are as follows:

1) Pick-up/drop-off trips account for an extremely high proportion in school-bound traveling, and the transportation modes used by people who take children to and from school are significantly different.

According to the RP results (Table 2), the current pick-up/drop-off rate for children in one-child households is close to 94%. However, the SP results show that with the changes in the household structure, most parents of elementary school students believe that the addition of the second child will add more burdens to parents regarding pick-up/drop-off. Some parents consider letting their two children to get to school together, but the rate of pick-up/drop-off is still over 80%.

Table 1 Questionnaire samples

Variable	Segmentation	Proportion/%	Variable	Segmentation	Proportion/%
Gender	Male	57.49	Household size	≤3	56.57
	Female	42.51		4	21.41
Grade of school-age child	1	15.93		5	18.96
	2	20.83		≥6	3.06
	3	18.02	Household disposable monthly income/CNY 10^4	≤0.5	11.93
	4	16.43		>0.5–0.8	21.10
	5	15.54		>0.8–1.0	22.32
	6	13.25		>1.0–2.0	27.53
Whether the household owns a car	Yes	78.96		>2.0–<5.0	15.29
	No	21.04		≥5.0	1.83

Note: For the convenience of the survey, the grade of a school-age child is taken as a substitute for the age. For example, Grade 1 students indicate 6-year-old or 7-year-old children with 6-year-old accounting for more than 90%; Grade 2 students indicate 7-year-old or 8-year-old children with 7-year-old accounting for more than 90%, and so on.

Table 2 Pick-up and drop-off of school-age children in different household structures %

Type	Household structure	Pick-up/drop-off Rate
RP	Only one child	93.89
SP	Two children—elementary/elementary school[1)]	88.99
	Two children—elementary/middle school[2)]	83.49

1) Households with two school-age children who are both attending elementary schools; 2) households with two school-age children, one attending the elementary school and the other middle school.

Those who take school-age children to and from school are mostly parents, and their travel modes vary significantly (Figure 1). Grandparents tend to walk or take public transit, while the travel modes adopted by parents are highly correlated with their commute modes. At the same time, for those parents, the proportion of private travel modes, especially cars, also rises.

2) Motorized trips account for more than 50% of school-bound traveling, and this proportion will grow further with the implementation of the two-child policy.

The RP results (Table 3) show that the proportion of motorized travel modes (electric bikes, cars, and public transit) of school-age children for school-bound traveling is 51.68%, which is greater than that of non-motorized travel modes (mostly walk and bikes). When the number of school-age children in a household increases, the proportion of non-motorized travel modes of them decreases significantly and that of motorized travel modes grows greatly.

3) The share of public transit is small in school-bound traveling.

With the larger number of school-age children in a household, the shares of cars and school buses in school-bound traveling will rise significantly. Moreover, the share of public transit will increase slightly, but it will still be significantly lower than that of private motorized travel modes (Figure 2).

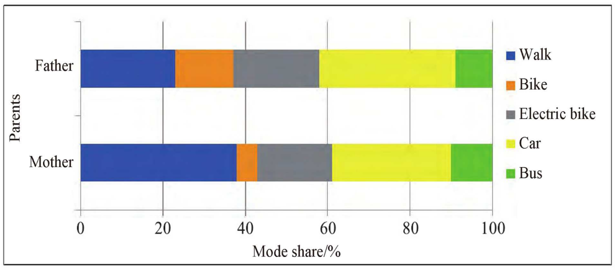

Figure 1 Shares of school-bound travel modes of different parents

Table 3 School-bound travel modes of school-age children in different household structures

Type	Household structure	Motorized travel mode/%	Non-motorized travel mode/%
RP	Only one child	51.68	48.32
SP	Two children—elementary/elementary school	62.79	37.21
	Two children—elementary/middle school	71.87	28.13

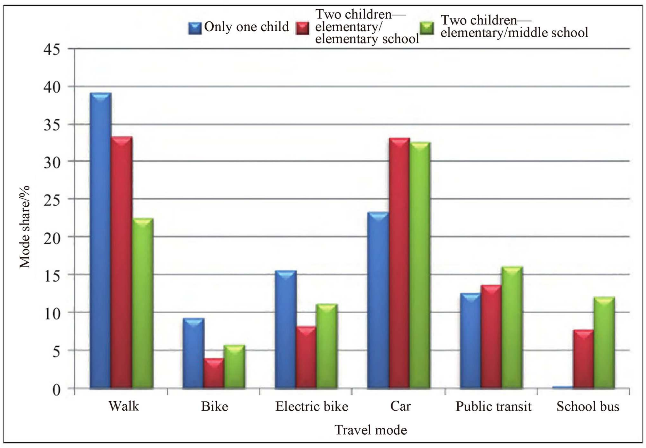

Figure 2 Travel mode share of school-age children in different household structures

2 Modeling and analysis of school-age children's school-bound traveling behavior

The above analysis reveals the main factors influencing the school-bound traveling behavior of school-age children. The Structural Equation Model (SEM) will be constructed below to quantify the impact of each influencing factor.

2.1 Basic principles

SEM is a statistical method to analyze the relationship between variables based on their covariance matrix. After comparing the difference in the covariance matrices of the hypothetical model and the actual survey data to test the relationship between the variables of the hypothetical model, SEM can consider and process multiple variables simultaneously and estimate the structure and relationship of factors at the same time. Furthermore, it can tolerate measurement errors in independent and dependent variables and estimate the degree of fit of the entire model. Thus it can well explain the complicated interrelationships among various influencing factors and those between influencing factors and travel behavior.

The application of SEM in the study of travel behavior generally does not involve latent variables, namely that any manifest variable has a corresponding latent variable. Therefore, the whole model only includes exogenous variables and endogenous variables. Exogenous variables are those that affect other variables but are not affected by other factors in the model; endogenous variables are those that are affected by both exogenous variables and other variables in the model. Exogenous and endogenous variables are represented by x and y, namely

$$y = By + \boldsymbol{\Gamma} x + \xi \text{ ,} \tag{1}$$

where $\boldsymbol{y}$ refers to the $m \times 1$ vector composed of m endogenous variables; $\boldsymbol{x}$ indicates the $n \times 1$ vector composed of n exogenous variables; $\boldsymbol{B}$ is an $(m \times m)^{\text{th}}$-order coefficient matrix; $\boldsymbol{\Gamma}$ is an $(n \times n)^{\text{th}}$-order coefficient matrix; ξ is the $m \times 1$ residual vector composed of the residuals of m structural equations.

2.2 Variable selection and model form

With a household as the analysis unit and considering the decision-making framework for a household with regard to school-bound traveling, the generation of school-bound traveling can be divided into two modules: decision-making of school-bound traveling and selection of travel modes. According to the previous analysis, household resource attributes, child attributes, parent characteristics and school-bound traveling environment are taken as the factors influencing school-bound traveling behavior. The details of variable selection and their descriptions are shown in Table 4.

With the households having two children attending the elementary school as an example, the specific forms of the models for decision-making of school-bound traveling and selection of travel modes are shown in Figure 3.

Table 4 Initial variables of the model

Classification	Type	Name	Abbreviation
Child attribute	Household resource attribute	Income	FMINC
		Household size	FMNUM
		Whether the household owns a car	FMCAR
	Child attribute	Gender of Child 1[1)]	CHI1SEX
		Grade of Child 1	CHI1GRA
		Distance to school of Child 1	CHI1DIS
		Traffic safety awareness of Child 1	CHI1TRACOG
		Grade of Child 2[2)]	CHI2GRA
	Parent characteristic	Whether they have a driver license	PLICENCE
		Whether school is on their way to work	PESCOCONV
		Whether they have flexible work hours	PFLEWORK
		Mother's commute time	MOTRAT
		Mother's travel mode	MOTRAM
		Father's commute time	FATRAT
		Father's travel mode	FATRAM
	School-bound traveling environment	Convenience of public transit	PUBCONV
		Traffic safety on the way to school	TRASAF
		Public order and security on the way to school	SOCSAF
Endogenous variable		Whether to take children to and from school	ESCO
	Travel mode	Walk	WALK
		Bike	BIKE
		Electric bike	EBIC
		Car	CAR
		Public transit	PUBTRA
		School bus	SCHBUS

1) Child 1 is the existing school-age child in the family; 2) Child 2 is the other school-age child in the family, or a hypothetical child.

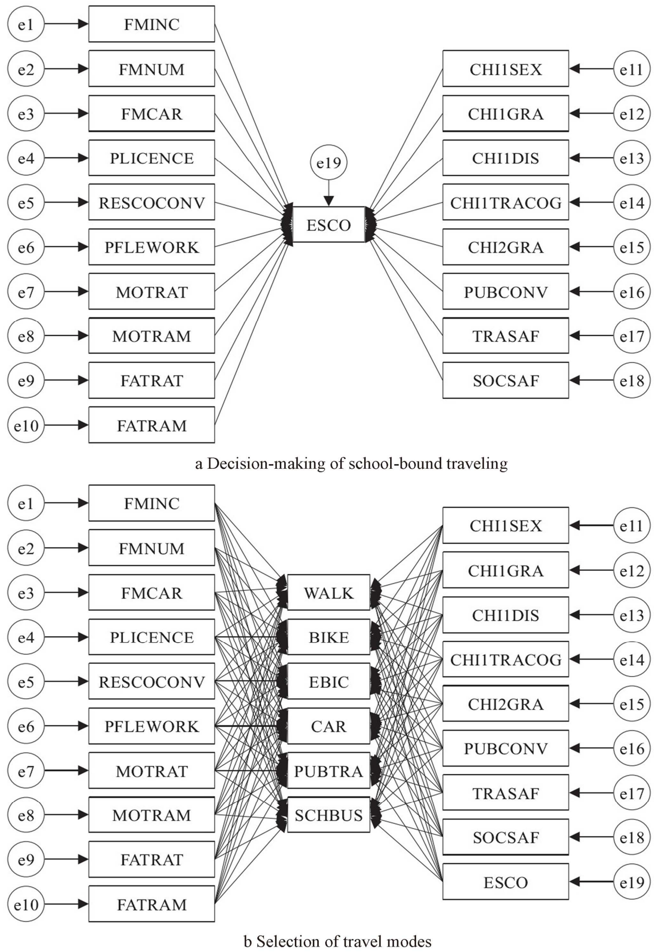

Figure 3 Relationship between models for decision-making of school-bound traveling and selection of travel modes regarding school-age children

2.3 Model results and verification

AMOS22.0 is used to estimate SEM based on Maximum Likelihood Estimation (MLE). MLE is the most common method for estimating the parameters of SEM. This estimation is unbiased, effective, and consistent, which is not affected by measurement units. The model results show that χ^2/df is 2.873, which is less than 3; GFI is 0.910, greater than 0.9; RMSEA is 0.072, less than 0.08. All these numbers meet the requirements, indicating that the model achieves the good overall fitting and the degree of fit between the theoretical model and the sample data is high. The detailed calculation results are shown in Tables 5–7.

2.4 Analysis of model results

1) Analysis of main factors affecting decision-making of school-bound traveling

The model results show that the age and traffic safety awareness of school-age children, the distance to school, traffic safety on the way to school, and parent's commute attributes are the key factors that affect the decision-making of school-bound traveling, i.e., whether to accompany school-age children to school.

Table 5 Impact of exogenous variables (child attributes and school-bound travel environment) on endogenous variables

Dependent variables	Independent variables							
	Child attribute					School-bound traveling environment		
	CHI1SEX	CHI1GRA	CHIDIS	CHI1TRACOG	CHI2GRA	PUBCONV	TRASAF	SOCSAF
ESCO	−0.063	−0.009	0.158	−0.126	−0.189	0.044	−0.175	−0.021
WALK	−0.095	0.005	−0.263	0.095	0.003	0.034	0.141	0.093
PUBTRA	0.078	0.022	0.105	0.025	0.060	0.132	0.060	−0.026
CAR	−0.004	0.006	0.222	−0.010	−0.013	−0.209	−0.019	−0.025
EBIC	−0.018	0.018	−0.078	0.014	0.001	−0.057	0.091	−0.053
BIKE	0.029	−0.045	−0.063	0.011	−0.023	−0.016	0.075	0.031

Table 6 Impact of exogenous variables (household resource attributes and parent characteristics) on endogenous variables

Dependent variables	Independent variables							
	Household resource attributes			Parent characteristic				
	FMINC	FMNUM	FMCAR	PESCOCONV	MOTRAT	MOTRAM	FATRAT	FATRAM
ESCO		0.053	0.072	0.059	−0.107	0.079	−0.013	0.035
WALK	−0.019	0.054	0.082	0.015	0.034	−0.177	0.067	0.043
PUBTRA	−0.068	0.023	−0.084	−0.086	0.019	0.146	0.046	0.081
CAR	0.103	−0.021	0.188	0.075	0.048	0.083	0.037	0.037
EBIC	−0.072	−0.008	−0.123	−0.025	−0.049	−0.039	−0.121	−0.075
BIKE	0.042	−0.023	−0.069	0.026	−0.025	−0.129	0.038	−0.031

Table 7 Impact of the exogenous variable (whether to take children to and from school) on endogenous variables

Dependent variable	Independent variable				
	WALK	PUBTRA	CAR	EBIC	BIKE
ESCO	−0.216	0.035	0.187	0.099	−0.017

As shown in Table 5, the parents of two-child households will consider the attributes of both school-age children when they make decisions for school-bound traveling. The influence coefficient of the grade of Child 2 on whether to take Child 1 to and from school is −0.189, indicating that when Child 2 is in a higher grade, some parents will let them get to school together, instead of picking them up. The influence coefficient of children's traffic safety awareness is −0.126, manifesting that the pick-up/drop-off rate will increase significantly when children's traffic safety awareness is poor. The influence coefficients of the distance to school and traffic safety on the way to school are 0.158 and −0.175 respectively, revealing that when the distance to school increases and traffic safety on the way to school is poor, the pick-up/drop-off rate will rise significantly.

In terms of parent's commute attributes, a mother has a greater influence on decision-making of school-bound traveling than a father (as shown in Table 6). Mother's commute time negatively affects the decision-making of school-bound traveling with an influence coefficient of −0.107. It shows that when the mother's commute time is long, the possibility to take children to and from school is significantly reduced. Moreover, the influence coefficient of a mother's travel mode on the decision-making of school-bound traveling is 0.079. It means when the mother's has a highly motorized commute mode, the possibility to take children to and from school is significantly raised. In addition, households with cars and large sizes are also more likely to take children to and from school, with influence coefficients of 0.072 and 0.053, respectively.

2) Analysis of main factors affecting selection of travel modes

Model results show that the distance to school, convenience of public transit, safety of travel environment, and the decision-making of school-bound traveling are the key factors that affect the selection of travel modes for school-bound traveling.

The distance to school has a positive impact on the travel modes of public transit and cars for school-bound traveling, with the influence coefficients of 0.105 and 0.222 respectively (as shown in Table 5). The positive coefficients indicate that a longer distance to school enlarges the demand for motorized travel modes and the dependency on cars. On the contrary, the influence coefficients of the distance to school on the travel modes such as walk and bikes are negative, indicating that the increase in the distance to school reduces the possibility of non-motorized travel modes for school-age children.

As shown in Table 5, the improvement in convenience of public transit significantly reduces the use of cars in school-age children's school-bound traveling, with an influence coefficient of −0.209. The improvement of traffic safety on the way to school will encourage the travel modes of walk, bikes and public transit, with influence coefficients of 0.141, 0.075 and 0.060, respectively. When there are two elementary school students in the household, parents pay more attention to public order and security on the way to school. A good environment of public order and security can promote the elementary school students to choose the walk mode to get to school, and the influence coefficient is 0.093.

Parent's decision-making of school-bound traveling also has a significant impact on the selection of travel modes of school-age children (as shown in Table 7). The households that take children to and from school greatly reduce the frequency of walk, with an influence coefficient of −0.216. On the contrary, they increase the frequency of cars and electric bikes, with the influence coefficients of 0.187 and 0.099.

3 Recommendations for optimizing school-bound traveling

The optimization of school-bound traveling is aimed at reducing the pick-up/drop-off rate of school-age children and inhibiting motorized traveling. According to the surveys and model results, the recommendations for urban planning and transportation system are made primarily from the perspective of reducing the distance to school, ensuring travel safety, and improving the diversity and convenience of transportation services for school-bound traveling.

1) It is recommended to reduce the serving radius of elementary and middle schools, pay close attention to the connection between elementary schools and middle schools, and reduce the travel distance to school. The above analysis results show that the distance to school is an important factor that affects both the decision-making of school-bound traveling and the selection of travel modes, and reducing the distance to school can significantly decrease the pick-up/drop-off rate and promote non-motorized travel modes. Corresponding measures include the following: In the planning process of elementary and middle schools, the serving radii of schools should be strictly controlled and the graduation and transportation service of the schools should be coordinated in accordance with the law of service radii. Besides, on the basis of strictly implementing the policy of attending the nearest schools in built-up areas, high-quality educational resources should be integrated and the connection of educational resources of elementary and middle schools should be established to make it possible for most school-age children to go to the nearest schools. These two measures can also improve the efficiency of parents with two children requiring pick-up and drop-off or make it possible for the two children to get to school together.

2) It is recommended to improve the safety level of school-bound traveling from various aspects, including transportation, society and environment, and reduce parent's anxiety about children traveling alone or with those at the similar age. The transportation environment, social environment and children's safety awareness significantly affect the decision-making of school-bound traveling of a household. Advocating the child-friendly school zones can lower the pick-up/drop-off rates of children and reduce the load on the urban transportation system. Corresponding optimization measures include the following: The space required for vehicles and pick-up and drop-off of children should be included as a reasonable planning indicator for planning the campus land; the traffic order should be regulated around school hours in school zones; the evaluation of traffic environment and social environment for school-bound traveling around school zones should be strengthened and it should be implemented as an important measure for the evaluation of traffic around new schools or established campuses; the education for children with regard to traffic safety should be enhanced and the deployment of police force should be increased around school hours in school zones.

3) It is recommended to provide diversified transportation services for school-bound traveling, give priority to the development of public transit, and optimize the structure of school-bound transportation. The implementation of the two-child policy will inevitably enlarge the overall scale of school-age children, and the pressure from the school-bound traveling will also grow. Improving the convenience of public transit can significantly lower the proportion of school-bound traveling by cars. Therefore, on the basis of providing diversified transportation services for school-bound traveling, priority should be given to public transit services, such as opening designated school-bound traveling routes, improving the coverage of public transit around schools, improving network services, giving fare discounts, providing customized shuttle buses, and running school buses. In terms of other social transportation services for school-bound traveling (such as car-hailing), for the safety of children and their maximal benefits, relevant laws and regulations should be formulated as soon as possible and the supervision system should be perfected, so that these transportation services can operate safely, legally, and in compliance with regulations.

4 Conclusion

This paper analyzes the school-bound traveling behavior of school-age children in two-child households based on RP and SP and quantifies the impact of various influencing factors. It also proposes management strategies and recommendations to optimize the transportation structure of school-bound traveling based on the model results, which can serve as a reference for policies in urban planning and traffic management after the implementation of the two-child policy. There are still some unresolved problems in the study. For example, due to the lag in the development of school buses in China at the current stage, the proportion of travel by school buses is still small and the impact of various factors on school buses is not significant in this model. Thus the endogenous variables of the use of school buses have to be eliminated from the model. However, the statistical analysis shows that the preference of two-child households for choosing school buses has increased significantly. Therefore, it is necessary to further study the main factors that affect the selection of the school bus and provide a scientific basis for popularizing school buses and planning bus routes.

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