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Research Article

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Analysis of factors influencing the severity of two wheeled vehicle collision accidents at intersections

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Abstract Due to the dense urban population, the road carrying capacity can not meet people's travel needs, more and more residents choose flexible two wheeled vehicles when facing short distance. In order to study the main characteristics and influencing factors of two wheeled vehicle accidents at intersections, this paper establishes a standard multinomial logit model by considering 9 factors, including the time of the accident, season, weather conditions, road conditions, visibility, drinking and retrograde violations, gender and the time of occurrence. The analysis shows that the lower the visibility, the greater the accident risk, and the weekend accident risk ratio increases. Illegal behaviors such as drinking and going retrograde significantly increase the risk of accidents, and weather that reduces visibility such as snow and fog will also increase the severity of accidents.

Keywords Two wheel vehicle, Accident severity, Standard multinomial logit model, influence factor

Introduction

With the increasing demand for travel and the serious problem of road congestion, more and more people take the initiative to choose two wheeled vehicles as a means of travel during short trips. In recent years, the output and sales of two wheeled vehicles have increased sharply. According to the economic operation analysis report of China's bicycle industry from January to June 2021 by the China Bicycle Association, the annual sales volume of electric bicycles in China is more than 30 million, and the social ownership is close to 300 million. In the first half of 2021, bicycles and electric two wheeled vehicles in China increased at a double-digit rate for two consecutive months. The output of bicycles was 25.187 million, an increase of 19.7% compared with the first half of 2020. The output of electric bicycles was 16.202 million, an increase of 34.2% year-on-year. According to the traffic accident statistics of the Traffic Management Bureau in 2019, a total of 69758 traffic accidents were caused by two wheeled vehicles such as bicycles, electric bicycles and motorcycles, causing 13959 deaths. Therefore, it is of great significance to study the main causes of two wheeled vehicle accidents for traffic safety management.

At present, there is little research on two wheeled vehicle accidents, but domestic and foreign experts and scholars have conducted in-depth research on traffic accidents. At present, the research methods for the analysis of accident influencing factors in the industry mainly include discrete selection model and nonparametric model. This paper selects a discrete selection model that can quantitatively analyze the severity of the accident. Therefore, the following is a review of the literature at home and abroad using discrete selection model to analyze the severity of accidents.

Gu Hongyan [1] and others used the ordered logit model to analyze the influencing factors of bus frontal collision accidents. The study found that whether on weekdays, driver gender, age, etc. have a significant impact

on the severity of the accident. The research results can help road managers formulate corresponding management measures to reduce accidents. In order to study the severity of traffic accidents among elderly drivers, Wen Huiying [2] and others selected 17 influencing factors to establish a standard multiple logit model, and found that whether to wear seat belts, gender, lighting conditions and so on were significantly related to the severity of accidents. Wang Tao [3] et al. Studied the factors that affect the severity of electric bicycle accidents, selected 19 independent variables to establish an ordered logit model, and analyzed 11 significant influencing factors. Among them, the behaviors of electric bicycle such as not following the road, speeding, drunk driving in violation of traffic regulations, not slowing down, turning left, crossing and colliding with trucks have the most serious impact on the severity of electric bicycle traffic accidents. Laura Eboli [4] et al. Distinguished different types of accidents and studied the impact of different factors on the severity. The study found that logit model can make an important explanation for the severity of the accident, which is conducive to the future safety improvement of Italy. Ali s AI Ghamdi [5] et al. Dichotomized the severity of the accident, analyzed nine influencing factors using logit model, and finally found that the location and cause of the accident had a significant impact on the severity of the accident. Considering the order of variables, Mahdi rezapour [6] et al. Established an ordered logit model to study the influencing factors of the severity of single vehicle accidents and multi vehicle accidents, and finally found that there was a substantial difference between single vehicle accidents and multi vehicle accidents. Wan he [7] et al. Studied the accident of urban river crossing tunnel and analyzed it with binary logit model. It was found that factors such as tunnel speed limit, accident location and number of vehicles had a significant impact on traffic safety, among which factors such as accident location and tunnel speed limit had a negative correlation on the severity of the accident. Zhiyuan sun [8] et al. Integrated binary logit model and classification and regression tree analysis, discussed the differences of accident influencing factors in different functional areas of the city, and found that the two factors of accident type and cross-sectional location are the two factors that have a great impact on traffic safety. Emmanuel Kofi adanu [9] et al. Developed four independent injury severity models. Using the mean and variance heterogeneity random parameter multiple logit model, they studied the causes of interstate traffic accidents, revealed the differences and similarities between different factors, and finally concluded that the location of the accident and the way of collision seriously affected the severity of the accident. Athanasios theofilatos [10] et al. Established two binary logit models to study the influencing factors of urban internal and external traffic safety, and found that bicycles, 18-30-year-old age group, and the location of the accident have significant effects only in the urban area, while frontal collision and weather factors have significant effects only outside the urban area.

So far, experts and scholars at home and abroad have produced rich research results, laying a theoretical foundation for the development of this study. However, most scholars aim to study the influencing factors and prediction of accident severity in different regions or different environmental factors, and there is less research on the location of the accident. This paper focuses on intersection accidents and analyzes the mechanism of intersection data fixation.

Data analysis and processing

The data of two wheeled vehicle accidents in Zibo from 2014 to 2019 are selected as the sample data. First, preprocess the accident data, extract the accident data at the intersection in the urban area, and eliminate irrelevant variables such as processors. Finally, nine important influencing factors such as the time of the accident, visibility, gender, week, season, time of occurrence, road conditions, drinking conditions and whether there is retrograde flow will be retained. Finally, 1301 collision accidents between two wheeled vehicles and cars at the intersection were obtained, accounting for 27.23% of all accidents involving two wheeled vehicles. In all samples, only property damage accidents account for only 2.08% of the total accidents, and injuries and fatal accidents account for 64.25% and 33.67% respectively. It can be seen that there is a great possibility of injury or even death in the collision between two wheeled vehicles and cars. The specific distribution is shown in Figure 1:

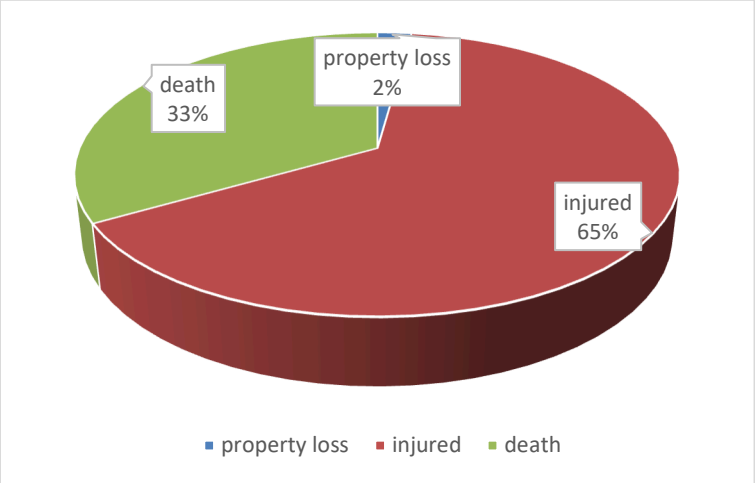

Figure 1: Proportion of accident types

Due to the influence of people's work and life, electric vehicle travel is also affected by it, which has certain time distribution characteristics. The accident data in the morning and evening peak hours is significantly higher than that in the normal peak hours. The number of accidents at night is very small, which is mainly related to the daily life of residents, and there are few vehicles for night travel. The change trend of accident volume in time is basically consistent with the traffic volume, showing a saddle shape, which indicates that there is a certain correlation between accident volume and traffic volume.

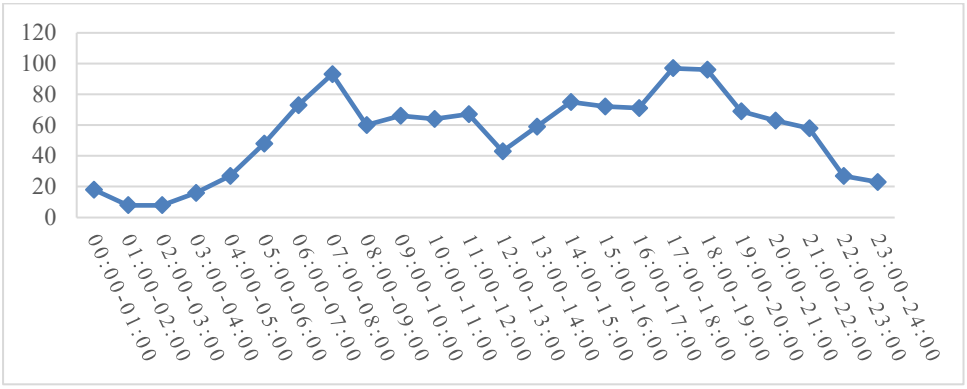

Figure 2: Period distribution

The number of two wheeled vehicle accidents on weekends is slightly higher than that on weekdays, but the gap is not large. Mainly due to the increase of weekend travel demand relative to weekdays, but the specific travel time is no longer concentrated in the peak period.

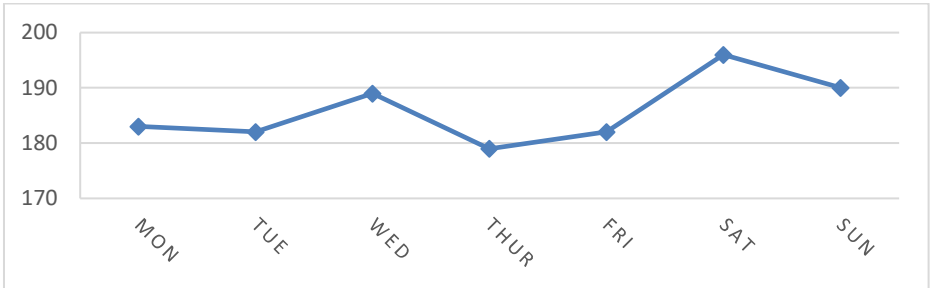

Figure 3: Distribution of accidents in each day of the week

The accidents of two wheelers and cars also show some imbalance in the monthly distribution. In January and February, due to the influence of weather and Spring Festival, the number of accidents is low. In March, April, may and June, the weather warmed up, the traffic flow stabilized, the demand for two wheeled vehicles increased, and the number of accidents also increased slightly.

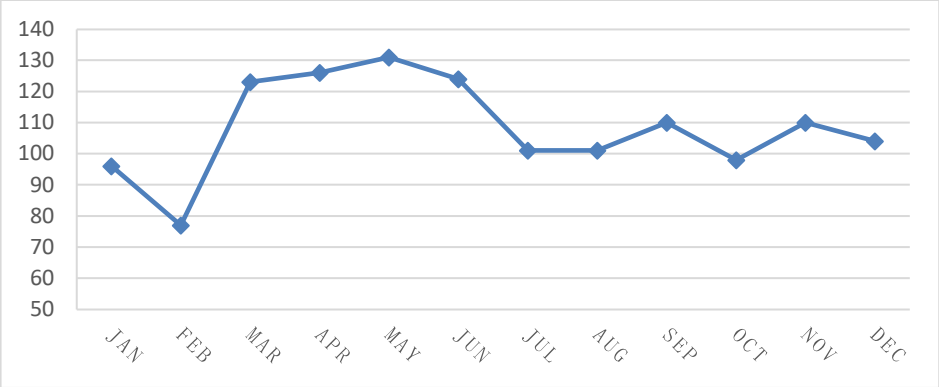

Figure 4: Monthly distribution of accidents

According to the weather distribution of accident data, sunny accident data accounted for 86.47%. This is inconsistent with people's cognition. Most people believe that accidents are more likely to occur in bad weather. In fact, the main reason is that the sample size of sunny days in a year is large, and most of the weather is sunny, so the total sample size of accidents in sunny days is high. The number of accidents with visibility above 200 meters is the largest, accounting for 51.96%, and the number of accidents below 50 meters is the smallest, accounting for 13.14% of the total number of accidents. There is no big difference between the number of accidents between 50-100 meters and 100-200 meters, but the death probability of accident personnel with visibility below 50 meters is as high as 39.18%, which is much higher than the death rate under other visibility conditions. Under the influence of weather conditions, the pavement condition is generally dry, accounting for 92%. In terms of gender, there is no significant difference in the accident data. Women account for 51.14% of the accidents and men account for 48.86%.

Data coding

In order to facilitate modeling research, variables are coded. All variables are coded beginning with 1, and all variables coded as 1 are taken as the benchmark variables of this influencing factor.

Table 1: Data coding

Variable name	assignment
Severity	1= property loss; 2= injured; 3= death
Occurrence period	1=[00 : 00, 07:00) ; 2=[07:00,10:00) ; 3=[10:00-16:00) ; 4=[16:00-19:00);5=[19:00-00:00)
Week	1= weekdays; 2= weekend
season	1= spring; 2= summer; 3= autumn; 4= winter;
weather	1= Sunny; 2= overcast; 3= rain; 4= fog; 5= snow
visibility	1=Below 50 meters; 2=50-100m; 3=100-200m; 4=More than 200 meters
Pavement condition	1= dry; 2= damp; 3= Ponding; 4= Ice and snow
Drunk driving	1= Not drinking; 2= drink wine
Retrograde	1= Retrograde; 2= Not retrograde
Gender	1= female; 2= Male

Model Building

In the study, the accident severity is divided into three categories, namely, only property loss accidents, injury accidents and fatal accidents. The binomial logit model is not suitable for this study, while the standard multinomial logit model has the advantages of binomial logit model.

The standard multinomial logit model is a discrete selection model built for multi category disordered variables. The explanatory variables only include personal attributes (independent variables that change only with individuals) and are mapped to independent variables in the sample of this study, such as gender. The standard multinomial logit model is similar to the binary logit model and is also based on the assumption of stochastic utility maximization. First, the utility function is introduced, as shown in formula (i):

$$T_{ij} = x_i\beta_j + \varepsilon_{ij} \quad (i = 1,2,\cdots,n) \qquad \text{(i)}$$

Where T_{ij} represents the utility of variable i to target variable$j$, x_i is the set of independent variables, β_j is the parameter related to the independent variable, $\varepsilon_{ij}$is a random error term.

When assuming ε_{ij}When obeys the generalized extreme value distribution, the standard polynomial logit model and variable x_i can be derived the probability of the target variable is shown in formula (ii):

$$p(Y_i = j|x_i) = \frac{\exp\,[\beta_j x_{nj}]}{\sum_{j\in J}[\beta_j x_{nj}]} \qquad \text{(ii)}$$

Construction of standard multiple logit model

Take the injury severity as the dependent variable, the type "1" in the injury severity as the reference variable, seven influencing factors as the independent variable, and the independent variable coded as "1" as the benchmark variable of the influencing factor. The maximum likelihood method is used to estimate the model parameters, and finally the standard multinomial logit model parameter estimation results are obtained, as shown in Table 2.

Table 2: Parameter calibration results

		Injury accident			**Fatal accident**		
Variable name	Classification statement	Coef.	OR	p	Coef.	OR	p
week	weekend	0.019	1.012	0.006**	0.0295	1.019	0.003**
season	summer	0.262	1.152	0.042*	0.140	1.089	0.011*
	autumn	0.183	1.116	0.007**	0.167	1.106	0.030*
	winter	-0.067	0.0958	0.214	-0.011	0.984	0.019*
weather	overcast	-0.129	0.0989	0.030*	0.154	1.092	0.039*
	rain	-	-	-	-	-	-
	fog	0.439	1.291	0.049*	0.103	1.065	0.049*
	snow	0.396	1.248	0.047*	0.030	1.019	0.021*
visibility	50-100m	-0.053	0.966	0.006**	-0.116	0.917	0.009**
	100-200m	-0.281	0.862	0.021*	-0.231	0.873	0.019*
	More than 200 meters	-0.432	0.767	0.036*	-0.302	0.839	0.009**
Road meter	damp	-	-	-	-	-	-
condition	Ponding	0.017	1.011	0.096	-0.019	0.982	0.076
	Ice and snow	-	-	-	-	-	-
Occurrence	07:00-10:00	0.544	1.344	0.043*	0.288	1.165	0.017*
period	10:00-16:00	-	-	-	-0.199	0.871	0.005**
	16:00-19:00	-0.243	0.873	0.038*	-0.784	0.569	0.028*
	19:00-00:00	-0.469	0.742	0.026*	-0.619	0.648	0.045*
Gender	Male	-	-	-	-	-	-
Drunk driving	Drunk driving	0.357	1.243	0.009**	0.392	1.272	0.019*
Retrograde	Retrograde	0.194	1.157	0.012*	0.187	1.211	0.006**

Note: in the p value, * means the significance level is less than 0.05, * * means the significance level is less than 0.01.

Result Analysis

This paper describes the influence of various factors on the severity of the accident through the or value and P value.

The probability of injury accidents on weekends is 1.012 times that of working days, and the probability of fatal accidents is 1.019 times that of working days. This is mainly because people have greater travel demand on weekends and the travel regularity is not obvious. The lower the visibility, the higher the accident risk. The probability of injury accident under 50-100m visibility is 0.966 times that under 50m visibility, and the probability of fatal accident is 0.917 times that under 50 visibility. The probability of injury accident at 100-200 meters is 0.862 times that below 50 meters, and the second fatal accident is 0.873 times. The probability of injury and death above 200 meters is relatively reduced. The probability of injury accident is 0.767 times that below 50 meters, and the probability of death accident is 0.839 times. Both drinking and retrograde dangerous driving behaviors will increase traffic risks. The probability of injury accidents caused by drinking and retrograde driving is 1.243 and 1.157 times that of non drinking and non retrograde driving, and the probability of fatal accidents is 1.273 and 1.211 times that of non drinking and non retrograde driving. The probability of accidents in summer and autumn is higher than that in spring, which may be caused by the unstable weather conditions at the beginning of spring, the less demand for electric vehicles, and the greater demand for migrant workers returning to the city in summer and autumn. Gender and road conditions have no significant impact on the severity of the accident.

After modeling and analyzing the eight influencing factors of week, visibility, gender, weather, quarter, time period, drinking and retrograde, it is found that dangerous behavior, visibility, week and weather have the greatest impact on accidents, so it is necessary to strengthen traffic control.

On weekends, the average daily number of accidents increases, and the probability of injury and death accidents increases. Therefore, strengthening traffic control on weekends is of great significance to reduce the occurrence or severity of accidents.

Visibility is mainly divided into four categories, namely, below 50 meters, 50-100 meters, 100-200 meters, and more than 200 meters. The lower the visibility, the higher the probability of injury or even death. In case of low visibility, people's vision becomes narrower. At this time, drivers should slow down and improve their vigilance.

The risk of accidents increases in bad weather. Rainy and snowy weather not only reduces visibility, but also causes slippery and waterlogged roads. Setting up eye-catching warning signs in waterlogged and icy sections is an effective measure to improve drivers' vigilance.

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