Amirkabir Journal of Civil Engineering

Amirkabir J. Civil Eng., 56(1) (2024) 23-26
DOI: 10.22060/ceej.2024.22108.7905

Identifying Types Of Freeway Crashes Using Nested Logit Model

A. Tavakoli Kashani[1,2], A. Rashidi[1,2*], S. Amirifar[1,2]

[1] School of Civil Engineering, Iran University of Science & Technology, Tehran, Iran
[2] Road Safety Research Center, Iran University of Science & Technology, Tehran, Iran

ABSTRACT: Road crashes and their consequences are one of the most important problems that affect people's lives. In order to reduce the fatalities and related costs of crashes, traffic safety researchers are continuously investigating approaches to reduce the occurrence and consequences of crashes. Crash-type modeling is one of the most common tools for road safety goals in transportation facilities, and the purpose of crash-type modeling is to establish a relationship between the frequency of crashes based on its type and other effective variables. One of the advantages of crash-type models is that with the help of these models, it is possible to identify the places where there is a possibility of a certain type of crashes and to examine the effect of different variables on different types of crashes. In this research, using the data of freeway crashes in Iran, the type of crash was identified with a new approach called the nested logit model. To this aim, crashes were initially divided into two categories of single-vehicle and multi-vehicle crashes, and then single-vehicle crashes were divided into three categories of collision with a fixed object, run-off road crashes, and overturning crashes, and multi-vehicle crashes were divided into two categories of collision with a vehicle and multi-vehicle collision crashes. Then the effect of different variables of environment, road, driver, and causes of crashes with different types of crashes were investigated and the effect of significant variables on each type of crash was explored with marginal effect.

Review History:

Received: Jan. 17, 2023
Revised: Nov. 29, 2023
Accepted: Jan. 06, 2024
Available Online: Jan. 24, 2024

Keywords:

Crash Type
Nested logit
Freeway Crashes
Traffic Safety

1- Introduction

Road crashes and their consequences are one of the most important problems that affect people's lives. Research studies show that until now the relationships between descriptive variables and the total frequency of crashes have been widely studied, while relatively less attention has been paid to the relationships between these variables and types of crashes[1].

The reason for the difference between different types of crashes is that the mechanism of occurrence of different crashes (for example, single-vehicle and multi-vehicle crashes) is different from each other. Therefore, the variables affecting different types of crashes will also be different. To solve the problems, researchers have used crash-type modeling[2, 3].

Crash-type modeling is one of the most common tools for implementing safety goals in transportation facilities. The occurrence of crashes is the result of the interaction between several variables, including road geometry, driver's behavioral characteristics, traffic conditions, and environmental characteristics, and the goal in modeling the type of crash is to establish a relationship between the frequency of crashes based on its type and other effective variables[4].

The research aims to develop the use of a nested logit model through the analysis of types of crashes, to investigate the factors affecting them with the help of modeling with this method, and to examine the results of the model in the freeways of Iran. For this purpose, a nested logistic regression model or nested logit model was used.

2- Data description

To carry out the research, the data on crashes in the last three years leading to the Corona pandemic in Iran's freeways were used. These data are collected from traffic police crash forms, which are recorded by the police officer after the crash. After cleaning and categorizing the data and removing the incomplete data, 10919 data remained, which included information about the driver and the characteristics of the crash involved.

3- Methodology

In order to measure the probability of occurrence, when the dependent variables are discrete, discrete choice models are used. One of the most prevalent of these models is Logit, which is widely used in safety. The advantage of these models

*Corresponding author's email:alitavakoli@iust.ac.ir

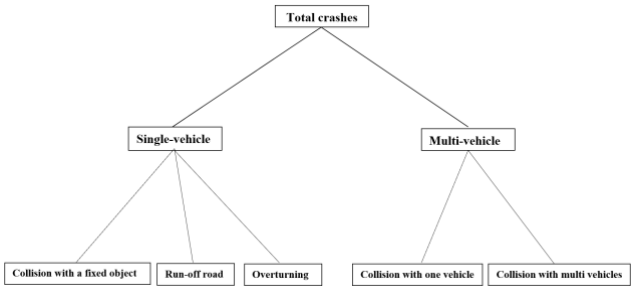

Fig. 1.Nested logit model structure

is the simplicity of modeling and interpretation of results compared to other discrete choice models (including the probit model). In the current research, due to the consideration of existing correlations between the output of various types of crashes, a special type of logit model called nested logit model is used, which was developed for this purpose. The structure of the model can be defined as follows [5]:

$$P_n(j) = P_n(j|i).P_n(i) \quad (1)$$

In The formula Pn(j), the unconditional probability is that crash (n) falls into the category of crash type j. Pn(i) is the unconditional probability that crash (n) falls into the nest of crash type i. Pn(j/i) is the probability is that crash n belongs to crash type j, which is a subset of the nest of crash type i.

4- Model processing

In order to proceed the nested model, the structure shown in Figure 1 was used; In this structure, the categories of crash type i include single-vehicle and multi-vehicle crashes, and the single-vehicle category is divided into three categories: collision with a fixed object, run-off road, and overturning. Also, the category of multi-vehicle crashes is divided into two categories of collision with one vehicle and collision with multi vehicles.

5- Discussion and Results

Marginal effects are used for each effective variable in the model to interpret the results. According to the definition, the marginal effect of a variable is equal to the change in the probability of the occurrence of a type of crash if that variable increases by one unit; For example, in the low level of the model and nest of single-vehicle crashes; The variable of weather condition has become significant in the utility function of collisions with fixed objects. The value of the marginal effect of this variable is equal to +4.74%, which means that if the weather condition variable increases by one unit (that is, if the weather condition variable changes from 0 to 1, or in other words, the condition the weather changes from normal to special conditions) in the single-vehicle crash nest, the probability of collision with a fixed object increases by 4.74%, which shows that the probability of collision with a fixed object in Weather with special conditions is more. However, at the lower level of the model and in the nest of multi-vehicle crashes, the "fatigue and drowsiness" variable has become significant in the utility function of collisions with a single vehicle, and its marginal effect is +14.15%, which states that if this factor was present in a crash, the probability of that crash being a collision with a vehicle increases by 14.15%. The shoulder width variable also has a marginal effect of -22.6% in the utility function of collisions with a single vehicle, and with the increase of the shoulder width, the probability of this type of crashes decreases.

But at the top level of the model, the investigation is between single-vehicle and multi-vehicle crashes. In the utility function of single-vehicle crashes, the variables of speed violation, inattention to the front, and the inability to control the vehicle have become significant causes, and their marginal effect is +40.59%, +20.79%, and +38.88% respectively. which are significant numbers, and the presence of these factors in a crash significantly increases the probability that it is a single-vehicle crash. But Among the variables of the causes of crashes in multi-vehicle crashes, variables such as "sudden change of direction" and "failure to observe the longitudinal distance" were significant, with marginal effects of +13.90% and +14.32%, respectively, This denotes that the probability of the multi-vehicle crash increases with these factors, the probability that the crash is multi-vehicle increases in a crash.

6- Conclusions

In the current research, a model was developed to predict the type of crashes on freeways in Iran. To consider the existing dependence between different types of crashes, the nested logit model was used. After modeling the results related to road and environment variables, it showed that the crashes where the crash position is outside the rider are more likely to be single-vehicle crashes, and among the single-vehicle crashes, there is a higher probability of run-off-road and overturning crashes. This shows the necessity of creating safety measures in rosd sections parts that are prone to crashes outside of the rider. For example, installing suitable guardrails with high flexibility can be effective. The probability of multi-vehicle crashes increases at night, which indicates a decrease in interaction between drivers at night, and the occurrence of these crashes should be prevented with proper road lighting. But among the human causes, the cause of disregarding the regulations increases the probability of run-off road crashes and overturning among single-vehicle crashes. The "fatigue and drowsiness" variable also significantly increases the probability of single-vehicle crashes and increases the probability of collision with a single vehicle in the nest of multi-vehicle crashes. In order to prevent driver fatigue and sleepiness, smart and warning systems can be used on cars. Among the causes of crashes, lack of attention to the front, which can be caused by distraction, significantly increases the probability of single-vehicle crashes. Also, the variable of

disobeying the longitudinal distance increases the probability of multi-vehicle crashes, which are dangerous crashes. Exceeding the safe speed and not being able to control the vehicle also significantly increases the probability of one-vehicle crashes. Suggestions to deal with these factors can be increasing the fine for violating the safe speed and preventing driving on freeways in the early years of driving.

Among the suggestions for future research, we can mention the investigation and combination of different types of crashes with different types of collisions (collision from the rear, from the side, head-on, etc.). For example, only single-vehicle crashes can be investigated, but according to the manner of collision, they can be placed in different nests. It is also possible to model the types of crashes in a specific road or a specific geographic environment and add traffic variables to them.

References

[1] A. Mahmud, V.V. Gayah, Estimation of crash type frequencies on individual collector roadway segments, Crash Analysis & Prevention, 161 (2021) 106345.

[2] T. Jonsson, J.N. Ivan, C. Zhang, Crash prediction models for intersections on rural multilane highways: Differences by collision type, Transportation research record, 2019(1) (2007) 91-98.

[3] V. Shankar, F. Mannering, W. BARFIELD,“, Effect of Roadway Geometrics and Environmental factors on Rural Freeway Crash Frequency, (1996) 371-389.

[4] Z. Christoforou, S. Cohen, M.G. Karlaftis, Identifying crash type propensity using real-time traffic data on freeways, Journal of Safety research, 42(1) (2011) 43-50.

[5] D. McFadden, Econometric models of probabilistic choice, Structural analysis of discrete data with econometric applications, 198272 (1981).

HOW TO CITE THIS ARTICLE

A. Tavakoli Kashani, A. Rashidi, S. Amirifar, Identifying Types Of Freeway Crashes Using Nested Logit Model, Amirkabir J. Civil Eng., 56(1) (2024) 23-26.

DOI: 10.22060/ceej.2024.22108.7905