A Study of Road Accidents Involving International Visitors: Case Study in New Zealand

Hyun-Chan KIM [a], Yuxin ZHANG [b]

[a] *Waikato Institute of Technology, Hamilton, 3240, New Zealand*
[a] *E-mail: chan.kim@wintec.ac.nz*
[b] *Waipa District Council, Waikato, 3840, New Zealand*
[b] *E-mail: david.zhang@waipadc.govt.nz*

Abstract: This study is to explore the driving behaviour of overseas drivers and to identify the key causes contributing to the road accidents in New Zealand (NZ) related to demographic and socio-economic characteristics of overseas drivers. A revealed preference (RP) survey of 205 overseas drivers is used to investigate whether overseas drivers' characteristics affect their ranked preference for attributes related to the risk of driving in NZ. The RP survey and rank-ordered logistics regression models identified the importance of various factors in determining the cause of accidents and providing some insight into issues that should be considered in accident reduction policy development. The results indicate that roundabout system brings confusion to Asian drivers, NZ's mountainous roads considered the most difficult terrain to overseas drivers, and fatigue after a long flight brings a moderate impact to the driver. Therefore, this study suggests that 'taylored' driving safety training programmes would be more effective to educate overseas visitors.

Keywords: Road accident, oversea drivers, revealed preference survey, rank-ordered logit model, New Zealand

1. INTRODUCTION

It is common that foreign visitors prefer to drive a vehicle when travelling around New Zealand (NZ). In terms of accessibility, driving a vehicle in NZ offers strong benefits when visiting a variety of locations, flexibility, time-saving etc. A recent study from the Ministry of Transport (MoT) shows that any individual holding a valid overseas driver licence or international driving permit is permitted to drive in NZ for up to 12 months (Ministry of Transport, 2015).

According to Crash Analysis System (CAS) data provided by the New Zealand Transport Agency (NZTA), the percentage of the road crashes involving foreign drivers has gradually increased from 0.7 per cent in 1994 to 4.2 per cent in 2012. Due to the privacy policy of NZTA, it can only reveal the involvement of overseas drivers in road crashes with no indication as to which party was responsible for the crashes. Statistics New Zealand has shown that the visitor number has gone up by nearly 22 per cent from 2005 to 2015 (Statistics New Zealand, 2015). With both the crash numbers and the visitor number increasing over time, it is expected that the number of road crash involving foreign drivers will follow the same path.

The primary objective of this study is to establish the areas of driving difficulties for foreign drivers in NZ. The CAS data over a five-year span, 2010 to 2014, has been extracted and analysed to determine the primary contributory factors of the crashes. Based on the literature review and CAS data analyses, five key contributory factors were revealed and categorised into the following four factors: road terrain, NZ road user rules, weather and fatigue. Consequently, the survey sought survey participants' ranking preferences to the above factors in terms of driving difficulty for them in NZ (Kim, 2015).

The secondary objective is to estimate the perceptions of overseas drivers driving on NZ roads. The revealed preference (RP) survey have been conducted to capture the various perceptions toward driving on NZ roads. The RP survey consists of a survey of 205 participants from different countries, made up of international students, tourists and migrants. General information (age, gender, nationality etc.) gathered from the respondents for further in-depth study based on each of the individual's characteristics. During the survey data analysis, the respondents were further split into different groups based on drivers' socio-demographic information including gender, age, country of origin, duration of stay in NZ, driving experience in the country of origin, and driving experience in NZ. A rank-ordered logit (ROL) model is adopted using data analysis on the choices of individuals over various options.

In this paper, we present a ROL model to examine the key causes contributing to the road accidents by overseas drivers. The data used in the empirical analysis are obtained from a revealed preference (RP) survey of 205 overseas drivers collected in NZ. The remainder of this paper is organised into sections. The remainder of this paper is organised into sections. Section 2 describes the historical road crash patterns based on NZTA's CAS database from 2010 to 2014. Section 3 explains the rank-ordered logit (ROL) model used in this study. Section 4 refers to the survey sample collected. Section 5 describes the estimation of a ROL model to identify the relative importance of causes contributing to the road crashes. The final section summarises the results and their implications.

2. NEW ZEALAND ROAD ACCIDENT: CRASH ANALYSIS SYSTEM

According to the data extracted from the Crash Analysis System (CAS) from 2010 to 2014, a total of 159,067 road crashes recorded in New Zealand (NZ), including 2,328 crashes were involving at least one overseas driver. A total of 1,356 fatal crashes and 9,087 severe-injury crashes were recorded in the CAS database with 36 fatal crashes and 198 severe-injury crashes involving overseas drivers respectively. Although 2.65% (36/1,356) of fatal crashes and 2.18% (198/9,087) of severe-injury crashes involving foreign drivers seems to be an insignificant number compared to the total number of crashes, the consequence of road crashes with at least one overseas drivers' involvement is rather different. Figure 1 shows that although there is a 0.84% possibility resulting in fatal crashes when no overseas driver was involved, the possibility of fatal crashes almost doubled when at least one foreign driver was involved in a car crash. The possibilities leading to severe/ minor injury crashes are also higher with foreign drivers' involvement.

The recent study published by NZ's Ministry of Transport (Ministry of Transport, 2015) indicated that overseas drivers were involved in 552 road crashes in 2014 while 425 road crashes were caused by foreign drivers.

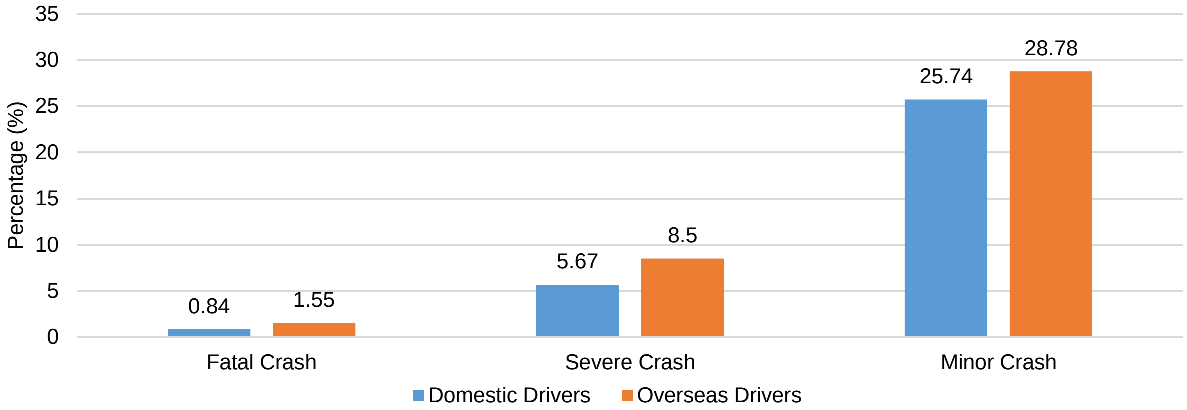

Figure 1. Crash comparison between domestic and overseas drivers

Figure 2 indicates that overseas drivers were responsible for 77% (425/552) of road crashes resulting in minor injuries, serious injury and 15 cases of fatal crashes. CAS data analysis revealed that the majority of the overseas drivers involved in all road crashes is made up of tourists (74%), followed by students (14%) and migrants (10%). However, there is no clear evidence whether the migrants were holding a NZ driver licence or an international driver licence.

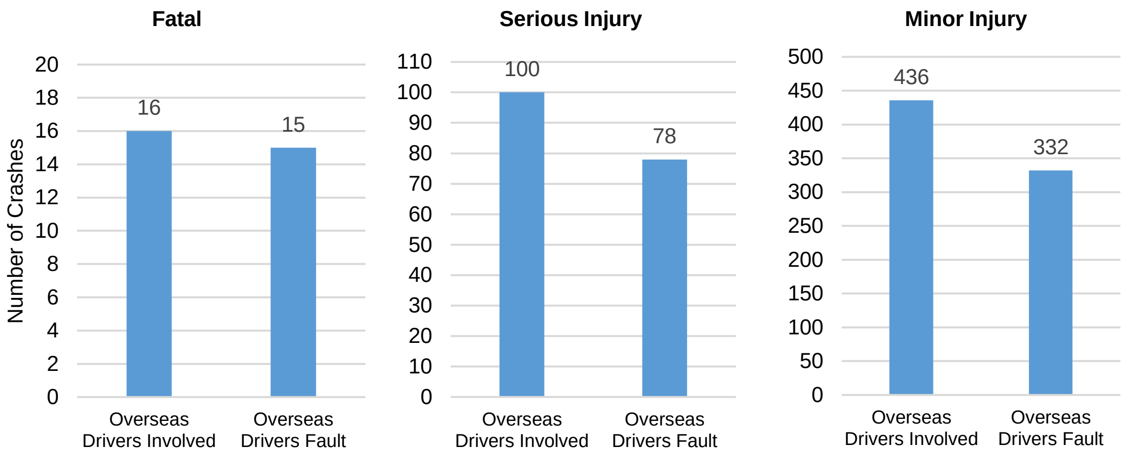

Figure 2. Party accountable for crashes

It has been reported that drivers coming from the countries used to drive on the right of the road failed to adjust to drive on the left-side of the road in NZ.

Table 1. Accident comparison: Caused by driving on the incorrect side of the road

	At least one overseas drivers	Solely domestic drivers
Crashes due to driving on the incorrected side of the road	96	369
Total crashes	2,328	156,739
Percentage (%)	4.12 %	0.24 %

Table 1 shows that a total of 2,328 crashes with overseas drivers' involvement recorded from 2010 to 2014, 96 were caused by drivers driving on the incorrect side of the road. This makes up 4.1% of total road crashes, while 369 (0.24%) crashes with the same cause were recorded with solely domestic drivers. However, due to the privacy policy of New Zealand Transport Agency (NZTA), there is no indication as to which party was responsible for driving on the incorrect side of the road.

Table 2. Severity of injury caused by driving on the incorrect side of the road

	Fatal crash	Severe injury	Minor injury	Total crashes	Percentage (%)
Overseas Drivers	3	24	54	81	84.38
Domestic Drivers	11	52	117	180	48.78

Table 2 shows the number of crashes and the severity of injuries sustained due to drivers driving on the incorrect side of the road. These results correspond to Table 1, and although the number of incidents with overseas drivers seems insignificant, the risk of severe injuries caused in accidents with at least one overseas driver involved is higher than in accidents involving domestic drivers.

A further investigation into the NZTA's CAS database was carried out to understand the main difference between overseas and domestic drivers when involved in road crashes. Figure 3 and 4 show a high similarity in terms of causes of accidents between domestic and overseas drivers, four of the five causes are identical but in different order.

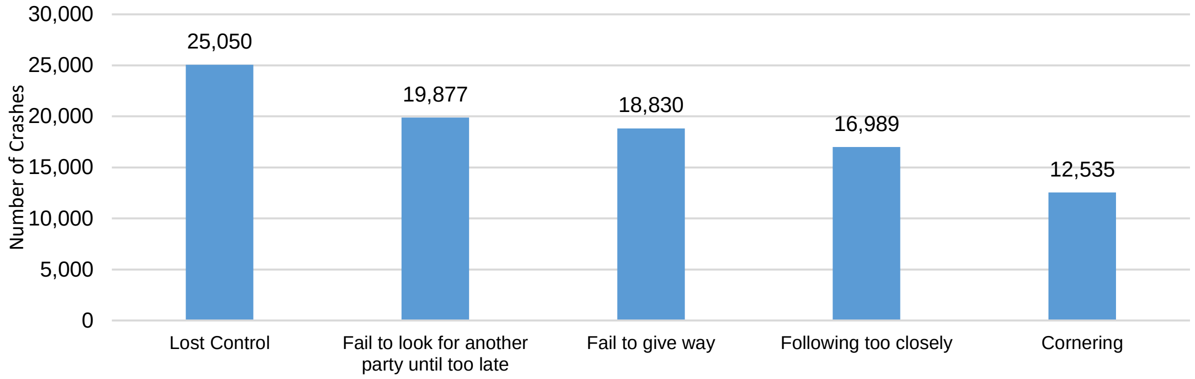

Figure 3. Top 5 contributory factors to crashes by domestic drivers

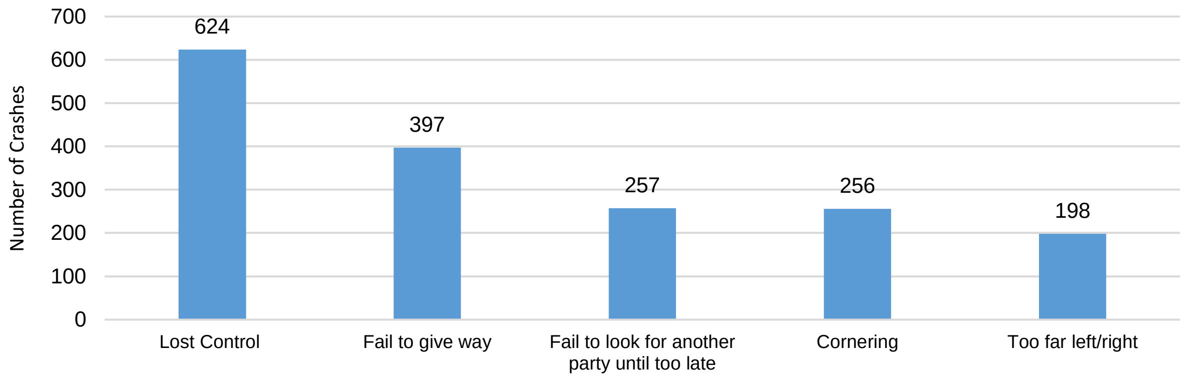

Figure 4. Top 5 contributory factors to crashes by overseas drivers

3. RANK-ORDERED LOGIT MODEL

The Rank Ordered Logit (ROL) Model is extended from conditional logit regression model introduced by Mcfadden (1974), further on developed by Pandj and Staelin (1978), Hausman and Ruud (1987), Chapman and Staelin (1982) and Allison and Christakis (1994).

The ranking approach may be seen as an attractive middle-ground between the rating and the single-choice approaches because the respondent provides a preference ordering of alternatives but not the relative degree of preferences (Sinivasan et al., 2006). Empirical applications describing preferences using the ROL model can be found in many fields such as voter preferences (Koop and Poirier, 1994), aging studies (Hsieh, 2005), marketing (Ahn et al., 2006; Dagsvik and Liu, 2006), medical decision making (Alava et al., 2013; Lemanske et al., 2010), environmental economics (Bishop et al., 2010), empirical labour economics (van Beek et al., 1997), school choice (Mark et al.,2004; Drewes and Michael, 2006), and demand for classical music (Van Ophem et al., 1999) and transportation studies (Calfee et al., 2001). Calfee et al., (2001) uses SP data in the context of estimating the value of automobile travel time. Beuthe and Bouffioux (2008) uses the ROL model in freight transport. More recently, Kim (2015) and Kim et al., (2014) use revealed preference (RP) data of transport to investigate NZ freight shippers' mode choice behaviour.

In random utility models, the rank of an alternative is determined by its utility, where the utility U_{ij} provided to individual i by product j is modelled as

$$U_{ij} = V_{ij} + \varepsilon_{ij} \tag{1}$$

where the error component ε_{ij} is assumed to be independently identically distributed (IID) with an extreme value distribution (Allison and Christakis, 1994), given by $Prob(\varepsilon_{ij} \leq t) = exp\{-exp(-t)\}$, and the probability of ranking j higher than k is given by

$$exp\{u_{ij} - u_{ik}\} \tag{2}$$

McFadden's random utility model implies the following likelihood L_i for a single respondent, where δ_{ijk}=1 if $Y_{ik} > Y_{ij}$, and 0 otherwise.

$$L_i = \prod_{j=1}^{J} \left[\frac{e^{V_{ij}}}{\sum_{k=1}^{j} \delta_{ijk} e^{V_{ij}}} \right] \tag{3}$$

Each of the terms in the product now has the term of a conditional logit model. The probability of item j being the most preferred item from the set J is

$$Pr(U_1 > U_j, j = 2, \cdots, J) = \frac{e^{V_1}}{\sum_{j=1}^{J} e^{V_j}} \tag{4}$$

When the first choice has been made, the second most preferred item can be chosen from the remaining $(\mathrm{J}-1)$ items. The probability of item j being the second most preferred item is

$$Pr(U_2 > U_j, j = 3,4, \cdots, J) = \frac{e^{V_2}}{\sum_{j=1}^{J} r} = \frac{e^{V_2}}{\sum_{j=1}^{J} e^{V_j}} \tag{5}$$

Because of the assumed independence between these choice tasks, the likelihood of a certain ranking of the alternatives in the entire choice set K is thus the product of J logit probabilities. This likelihood can be written as

$$Pr(U_1 > U_2 > \cdots > U_j) = Pr(U_1 > U_j, j = 2, \cdots, J) \bullet Pr(U_2 > U_j, j = 3, 4, \cdots, J) \bullet Pr(U_3 > U_j, j = 4, 5, \cdots, J) \cdots \bullet Pr(U_{J-1} > U_J)$$

$$= \frac{e^{V_1}}{\sum_{j=1}^{J} e^{V_j}} \bullet \frac{e^{V_2}}{\sum_{j=2}^{J} e^{V_j}} \bullet \cdots \bullet \frac{e^{V_{J-1}}}{\sum_{j-1}^{J} e^{V_J}} = \prod_{j=1}^{J-1} \left[\frac{e^{V_J}}{\sum_{m=j}^{J} e^{V_m}} \right]$$

$$Pr(U_1 > U_2 > \cdots > U_K, K \leq J) = \prod_{j=1}^{K} \left[\frac{e^{V_j}}{\sum_{k=j}^{K} e^{V_k}} \right] \tag{6}$$

Finally, estimation of a ROL model can be accomplished with most partial likelihood procedures for estimating proportional hazard models. For a sample of n independent respondents, above equation implies a log-likelihood of

$$\log L = \sum_{i=1}^{n} V_{ij} - \sum_{i=1}^{n} \log[\sum_{k=1}^{j} \delta_{ijk} \exp(V_{ik})] \tag{7}$$

The ROL model was used to analyse the statistical data collected from the revealed preference survey. ROL model is used to analyse the preferences of individuals over a set of alternatives, where preferences are partially observed through the survey or conjoint studies (van Dijk et al., 2007). In the survey, respondents were asked to rank the factors identified instead of choosing the preferred option and using the ROL model, the parameters of the choice model and preferences can be estimated more efficiently. Unlike the traditional statistical analysis that only provides the percentage of each option being chosen by the survey participants, ROL model is used to determine the possibilities of each choice being chosen compared to a base point. It requires one factor to be set as the base point, and then comparisons will be made between every other factor to the base factor, in order to determine how much more or less likely the other factors to be chosen compared with the base point.

Allison and Christakis (1994) used the PHREG procedure of SAS®. This approach is also found in Asch et al., (1999), Allison (1999), Lim (2002), Kumar and Kant (2007), Zhang et al., (2010), Kim (2015), and Kim et al., (2014). Allison and Christakis (1994) provide the detailed discussion on exploiting identities in the likelihoods between the proportional hazards model and the ROL model by using the maximum likelihood procedure. The statistical software SAS® was used to estimate the ROL model. As pointed out by Allison and Christakis (1994), estimation of a ROL model is based on a maximum likelihood procedure that can be easily accomplished with most partial likelihood procedures for estimating proportional hazard models (Cox, 1972; Cox and Oakes, 1984; Hsieh, 2005; Alava et al., 2013; Kim, 2015; Kim et al., 2014).

The first task was to estimate a model that allowed for differences between four driving factors but no differences among respondents. The model assumed that all sample had an equal probability distribution of item preferences and the differences between rankings were only due to random variation. The results generated by ROL model will be focusing on the values of the Exponent of coefficient, it is a value indicating the possibilities of one specific group selecting one specific option over the datum option. One more feature of the ROL model is that the results are reflective, which means when the survey sample is put into two group for analysis when one specific group has been examined, the result for another group can be determined using 1 divided by the exponent of coefficient.

4. DATA ANALYSIS

For this study, the targeted survey participants were individuals driving in New Zealand (NZ) holding either an international driver licence or an international driver permit. Survey data on the relative preference of driving difficulty was obtained from mainly overseas tourists, international students, and a few migrants who have recently settled in NZ. A revealed preference (RP) survey was conducted face-to-face in 2015. The survey sample was randomly chosen from different popular tourist spots in the North Island such as Hamilton, Rotorua, Napier and Gisborne.

The survey was tested at Auckland International Airport with several questionnaire designs and in each case, a thorough pre-test pilot with industry and academic professionals was conducted prior to the main survey. A survey of 205 participants was undertaken with the finalised survey data form. Participants were mainly approached by surveyors in the streets, at tourist' attraction points and I-Site centres. Overseas drivers in NZ have individual characteristics that have an influence on their driving abilities. In the survey, the respondents were asked to complete questions regarding their individual characteristics. The objective of the RP survey was to identify how strongly overseas drivers' socio-demographic characteristics, such as gender, age, country of origin, their driving experience in country of origin and NZ, the duration of their visit in NZ, the purpose of their visit and the ownership of the vehicle used in NZ, influence driving on NZ's road. To address these influences, seven individual characteristics of overseas drivers were introduced into the model using this socio-demographic information.

Table 3 demonstrates the distribution of survey respondents among the various socio-demographic characteristics. Of the 205 overseas drivers who responded 55% are male. Most participants are within the age group of 21 to 30. In terms of country of origin, participants for this survey come from more than 15 different countries, 62% of respondent come from Australia, China and India. 74% of all participants come with driving experience in their country of origin, while only 18% had previous driving experience in NZ. The respondents were categorised into different groups based on the respondents' socio-economic characteristic. In terms of age, 59% of respondents were categorised as a young drivers group (age under 30). NZ is a country with traffic on the left-hand side of the road, while many other countries drive on the opposite side. In this survey, 60% of respondents indicated that they came from countries driving on the right-hand side of the road, such as China, the Philippines and the U.S.A., etc. The remaining 40% of respondents come from countries where traffic is also on the left-hand side such as Australia, India and the U.K.

Through observation of the responses, nearly half of the survey participants have driving experience in NZ of more than one month, while the remainder of respondents' experience varies from less than one week to less than one month. The survey participants were split into long-term visitors and short-term visitors based on the purpose of their visit. Participants who are in NZ for study or work are categorised as long-term visitors, while the rest are considered short-term visitors such as tourists.

Table 3. Sample statistics

General Information	Description	Number of Respondents
Gender	Male	113
	Female	92
Age	Less than 20	15
	21 – 30	106
	31 – 40	44
	41 – 50	25
	51 – 60	12
	61 and Over	3
Nationality	Australia	33
	UK	11
	China	56
	India	39
	USA	14
	Philippines	14
	Other	38
Driving experience in country of origin	None	28
	Less than one year	46
	1 – 5 years	78
	6 – 10 years	35
	Over 10 years	17
Driving experience in New Zealand	Less than one week	23
	1 – 2 weeks	37
	2 – 4 weeks	39
	1 – 3 months	27
	Over 3 months	75
Purpose of visit	Visit friends or relatives	38
	Business/Conference	13
	Education	88
	Holiday	57
	Immigration	9
Car Ownership	Rental	70
	Purchased	104
	Other	31

Out of all survey participants, 104 respondents purchased the vehicles used in NZ, while the rest either rented the vehicles or operated vehicles owned by their friends, relatives or business partners. Interestingly, over 50% of respondents purchased the vehicle. This could be explained that the survey sample includes visitors under the working holiday scheme which allows young tourist, usually aged 18-30 to travel around NZ with the ability to work up to 12 months, or 23 months if visitors are from the UK or Canada. A total of 65,220 people was approved to work in NZ under this schemes in 2015/2016 (MBIE, 2016). Purchasing a used car in NZ could be a cost-effective transport option if visitors are planning on staying for a few months or more.

5. RANK-ORDERED LOGIT ANALYSES FOR THE KEY CAUSES CONTRIBUTING TO THE ROAD ACCIDENTS BY OVERSEA DRIVERS

5.1 The Perceived Causes of Road Accidents

A Revealed preference (RP) survey was undertaken, and responses were received from 205 participants. The survey consists of two parts: general information of participants and to rank factors in terms of the driving difficulty against over three to four alternatives. The rank-ordered questions firstly asked participants to rank four factors (Table 4) in terms of driving difficulty when driving in New Zealand (NZ) from 1 (most difficult) to 4 or 5 (least difficult).

Table 4. Various factors in driving difficulties

Factors	Descriptions
Road terrain	Various types of road in NZ
NZ road user rules	Road user rules in NZ compared to driver's country of origin
Weather	Different weather conditions e.g. rain, sun, snow and fog
Fatigue	Level of impact caused by fatigue when driving

The question is then followed by four sub-questions in regard to each option. Two optional open questions were listed at the end regarding differences in driving between NZ and the participant's country of origin and comments/ suggestions regarding their driving experiences. Each of the questions included three types of data: (1) a unique identification number for each respondent; (2) the rank assigned by each respondent to the NZ's road environment factors; (3) a group of 3 dummy (or indicator) variables in accordance with 3 of the 4 different options (the 'base point' or 'reference' factor, road terrain for overall, is omitted).

First, a rank-ordered logit (ROL) model was estimated, allowing for differences between four variables of road terrain, understanding of road user rules, weather and fatigue, but making no differences between participants. It is assumed that each respondent in this study possesses equal possibility distribution among the variables and the observed differences in the rankings were due only to random variation. Table 5 illustrates the likelihood estimation of the coefficient for each option, for the whole dataset.

Table 5. Rank-Ordered logit model (Overall)

	Variables	**Estimate of Coefficient**	**S.E.**	**Exponent of Coefficient**	**Mean Rank**
Overall	Road terrain (base)	0.000	0.000	1.000	2.42
	Road user rule	*-0.202	0.251	0.817	2.68
	Weather	0.056	0.254	1.057	2.40
	Fatigue	-0.096	0.255	0.908	2.51
Wald χ^2: 5.273, DF:3, p<0.1529					

***p<0.01, **p<0.05, *p<0.10

It should be noted that, in the first dataset, the road terrain is the 'base' (or 'reference'), and is assigned a coefficient of zero, with the coefficients for the other choices being either positive or negative. The coefficients, along with the standard error (S.E.) of estimation, indicate whether the option has a statistically significant effect. The Wald chi-squared (χ^2) test is used to assess the overall statistical significance of the data, and the exponent of coefficient is to identify the difference in a possibility of an option being chosen. The null hypothesis is that every variable contains the same importance.

Table 6 provides the maximum likelihood estimate from the ROL model for the sub-factors. Similar to the modelling approaches in Table 5, every sub-factor contracts with the reference category; highways, give way and drizzle are the dummies (reference points) to each individual category.

Table 6. Rank-ordered logit model (Sub-factors)

	Variables	**Estimate of Coefficient**	**S.E.**	**Exponent of Coefficient**	**Mean Rank**	**Goodness of fit**
Road terrain	Highway (base)	0.000	0.000	1.000	2.80	*Wald χ^2: 62.676 DF:3 p<0.0001*
	Rural roads	***0.419	0.125	1.520	2.44	
	Mountainous roads	***0.874	0.130	2.397	1.96	
	City centre	-0.036	0.128	0.947	2.80	
Road user rules	Give way (base)	0.000	0.000	1.000	2.51	*Wald χ^2: 37.548 DF:3 p<0.0001*
	Stop sign	-0.133	0.122	0.875	2.60	
	Roundabout	***0.420	0.124	1.522	2.07	
	Keep left	***-0.342	0.128	0.710	2.81	
Weather	Drizzle (base)	0.000	0.000	1.000	3.83	*Wald χ^2: 122.380 DF:4 p<0.0001*
	Fog	***1.152	0.129	3.164	2.54	
	Heavy Rain	***1.326	0.133	3.767	2.35	
	Snow	***0.527	0.128	1.694	3.22	
	Sunstrike	***0.691	0.129	2.000	3.02	

***p<0.01, **p<0.05, *p<0.10

Again, the overall rank order results are largely consistent with the mean ranks. Table 6 shows that overseas drivers are significantly likely to select the option of rural and mountainous roads as being difficult for driving, and yet apparently do not feel constrained by driving in the city centre.

On average, overseas drivers ranked roundabouts as the greatest challenge they have faced in terms of NZ road user rules, with driving on the left being ranked as less significant than using give way. It is indicated that unfamiliar weather conditions affect respondents' driving performance. In terms of different types of weather, the results for each selection show statistical significance; heavy rain has 3.77 times the chance of being chosen than drizzle, followed by fog (3.16 times), sunstrike (2 times) and snow (1.694 times).

5.2 The Perceived Causes of Road Accidents between Groups

The preceding model assumed that every respondent included in this study had the same probability distribution of mode choice preferences and that the observed differences in their rankings were due only to random variation. This subsection examines and extends the model to capture the heterogeneity in mode choice preference across responding individuals.

To capture the effects of the overseas drivers' characteristics on their constraints to driving in NZ, the socio-demographic information mentioned above was used to split the respondents into different groups. The products of each of the six dummy factors and each of these six characteristics variables were included in the ROL model.

Table 7 presents a description of the explanatory variables and their coding. The null hypothesis is that all product interactions between the six dummy factors and the explanatory variable have zero coefficients. Therefore, a simplistic model allowing for differences in hazard factor preferences across driver's characteristics was used. For example, for a group of drivers distinguished by gender, the deterministic component of utility can be written as $V_{ij} = \beta_{1j} x_i$, where $x_i = 1$ if the group of drivers is male, and 0 indicates a group of female drivers.

Table 7. Description of explanatory variables

Characteristic	Code	Descriptions and coding
Gender	Gen	1 = Male
		0 = Female
Age	Age	1 = Drivers younger than 30 years of age
		0 = Aged over 30
Country of Origin	Coo	1 = Left-hand drive
		0 = Right-hand drive
Duration of stay	Dos	1 = Duration of stay in NZ less than 3 months
		0 = Duration of stay in NZ over 3 months
Driving experience in country of origin	Dco	1 = A drivers has less than 6 years of driving experience
		0 = Driving experience of 6 or more years
Driving experience in New Zealand	Dnz	1 = A drivers has less than 1 month of driving experience in NZ
		0 = Driving experience of 1 month or more in NZ

Note again that one of the four driving condition factors must be set as a reference factor for achieving identification in the model estimation and the road terrain factor was used for measuring overall perception. Thus, the utility associated with the driver's characteristics on the age (age) with drivers younger than 30 years of age will be (Punj and Staelin, 1978; Allison and Christakis, 1994):

$$\begin{aligned} U_{ij} = {} & \left(\beta_{terrain} x_{terrain} + \beta_{rule} x_{rule} + \beta_{weather} x_{weather} + \beta_{fatigue} x_{fatigue}\right) \\ & + \left(\beta_{age_{terrain}} x_{age_{terrain}} + \beta_{age_{rule}} x_{age_{rule}} + \beta_{age_{weather}} x_{age_{weather}} \right. \\ & \left. + \beta_{age_{fatigue}} x_{age_{fatigue}}\right) \end{aligned} \tag{8}$$

where, $x_{age_{terrain}} = x_{age} * x_{terrain}$, $x_{age_{rule}} = x_{age} * x_{rule}$, $x_{age_{weather}} = x_{age} * x_{weather}$, and $x_{age_{fatigue}} = x_{age} * x_{fatigue}$.

For the coefficient of the driving factors interacting with the individual respondent's characteristics indicated as statistically significant, the quantity (Exponent of coefficient) was computed. This gives the percentage change in the odds of preferring that choice factor over each other respondent group, for each percentage increase in the exponent of coefficient.

Table 8 presents the modelling results retrieved from the socio-economic groups with statistically significant variables which are;

- Group aged under 30
- Group of long-term visitors
- Group that comes from countries that drive on the right, and
- Group that has more than one month of driving experience in NZ

For the survey participants aged under 30, it is considered that fatigue is not a strong factor (0.65 times) compared to road terrain when driving in NZ. Due to the reflective nature of ROL modelling, this can be interpreted as showing fatigue has 1.55 (*exp(0.438)*) times more possibility of being chosen than road terrain by the opposite group (aged above 30). The results from this group regarding road terrain sub-factors shows a slight variance from the result of the overall analysis (Table 5), as highway is considered the least important factor, while mountainous roads are considered the most significant driving condition, 2.46 times compared to highway, followed by city centre (2.05 times) and rural roads (1.81 times). The results also show that regarding the sub-factors of road user rules, young respondents (aged under 30) are 1.7 times more likely to select roundabout than to select give way rule.

For long-term visitors, it has been considered that mountainous roads and roundabouts are most likely to be ranked as presenting the highest difficulties in each category. Note that the dummy variables for the duration of stay have been set up to be 3 months. Because under the NZ immigration law, the visitors are normally granted tourist visa up to a period of three months. The ROL model also revealed that keeping left for respondents from right-hand-side driving countries is a challenge. Table 8 also shows that the option keep left has 1.93 times the possibility of being selected as the give way option. Finally, the overseas drivers who had driving experiences of over one month in NZ show the ability to drive in heavy rain. Note also that the dummy variable for the driving experience has been set up to be 1 month based on the report from the Tourism Industry Association NZ (TIA, 2015). The report indicated that the international visitors from the key countries such as China, U.S, U.K, Japan and Germany spent on average 27 days in NZ.

Table 8. Rank-ordered logit model: Repsondents' socio-demographic characteristics

	Variables	Estimate of Coefficient	S.E.	Exponent of Coefficient	Mean Rank	Wald χ^2
Age: Under 30						
Overall	Road terrain	0.000	0.000	1.000	2.42	0.000
	Rule	0.092	0.251	0.912	2.68	0.135
	Weather	-0.369	0.254	1.446	2.40	2.100
	Fatigue	*-0.438	0.255	0.645	2.51	2.947
Road Terrain	Highway	0.000	0.000	1.000	3.04	0.000
	Rural roads	**0.596	0.252	1.814	2.40	5.558
	Mountainous roads	***0.899	0.264	2.457	1.83	11.572
	City centre	***0.718	0.263	2.050	2.74	7.425
Road Rule	Give way	0.000	0.000	1.000	2.55	0.000
	Stop sign	-0.015	0.251	0.985	2.65	0.003
	Roundabout	**0.518	0.253	1.679	1.89	4.182
	Keep left	-0.165	0.259	0.848	2.88	0.407
Duration of stay: Long-term visitors						
Road Terrain	Highway	0.000	0.000	1.000	2.89	0.000
	Rural roads	0.103	0.253	1.109	2.48	0.165
	Mountainous Roads	**0.629	0.266	1.876	1.88	5.584
	City centre	0.212	0.261	1.237	2.74	0.662
Road Rule	Give way	0.000	0.000	1.000	2.58	0.000
	Stop sign	0.242	0.249	1.273	2.55	0.944
	Roundabout	*0.486	2.255	1.626	1.96	3.644
	Keep left	0.140	0.260	1.150	2.89	0.288
Country of origin: Drive on the right						
Road Rule	Give Way	0.000	0.000	1.000	2.51	0.000
	Stop Sign	-0.036	0.245	0.964	2.60	0.022
	Roundabout	0.213	0.250	1.238	2.07	0.729
	Keep left	**0.659	0.259	1.933	2.81	6.437
Driving experience in NZ: More than one month						
Weather	Drizzle	0.000	0.000	1.000	3.78	0.000
	Fog	0.213	0.261	1.238	2.38	0.669
	Heavy Rain	*-0.479	0.268	0.620	2.48	3.194
	Snow	-0.328	0.259	0.720	3.29	1.607
	Sunstrike	-0.273	0.262	0.761	3.07	1.084

***p<0.01, **p<0.05, *p<0.10

6. CONCLUSIONS

Initially, Crash Analysis System (CAS) data provided by the New Zealand Transport Agency (NZTA) was been extracted to study the contributory factors to road crashes involving overseas drivers. Five key factors have been determined and categorised as road terrain, New Zealand (NZ) road user rules, weather and fatigue. A revealed preference (RP) survey of 205 participants was then undertaken to collect foreign drivers' perceptions in regards to the driving difficulty in NZ. The survey data was analysed through the rank-ordered logit (ROL) model to quantify the choice preferences of the respondents.

The results from ROL model has shown that road terrain was considered the most difficult factor when driving in NZ, while mountainous roads are the most challenging road terrain for driving. This is mainly due to many of the roads outside of the major cities in NZ are two lanes, without barriers between the two directions, and include narrow, windy, sharp curves and hilly terrain. In addition, many of country roads have varying conditions with unsealed gravel roads. When driving on the South Island particularly, although the driving distances between main cities and tourist attractions may seem short, NZ road terrain can slow down vehicle speed, increase total travel time and increase the chance of accidents. Although, roundabouts have traditionally been used for intersection control in NZ, approaching a roundabout (may include a multi-laned roundabout) has been revealed to be the most difficult NZ road rule for overseas drivers, while keeping left has a lower level of complication for the respondents. In many countries, the number of roundabouts has increased in the last decade, however, many overseas visitors such as the U.S. and Japan are most likely to stumble upon a roundabout.

In terms of the weather and climate change in NZ, the overseas drivers have experienced that the heavy rain causes the most difficult driving conditions, followed by fog, sunstrike, snow and drizzle. The results further indicate that fatigue has a moderate impact on the drivers. The results from most of the in-depth analysis with various socio-demographic groups has shown consistency in the general analyses. It has shown that respondents aged above 30 tended to believe that fatigue brings a higher level of difficulty in driving than road terrain. Survey participants who came from right-hand-side driving countries have 1.93 times the possibility choosing keep-left compared to the rest of the respondents. The results from the model also suggest that the experience of driving in NZ for more than one month reduces the driving difficulty brought about heavy rain.

For improvements to the road network safety system, it is recommended that protection measures be taken according to the analysis results. For a lower budget approach, education and(or) brochures regarding NZ's diverse road conditions and terrains, mainly in mountainous and rural areas, could be provided to overseas drivers to raise awareness; and a theory test given to overseas driver could be an option to raise knowledge of NZ road user rules. Therefore, this study suggests that 'taylored' driving safety training programmes would be more effective to educate overseas visitors while the cause of accidents is more specific to the socio-demographic characteristics of overseas drivers such as age, country of origin, and their experience driving in their country and NZ**.** In terms of the rules and regulations, the car insurance or rental car company will need better systemic screening tools and assessment programmes to detect a high-risk driver. Subsequently, a compulsory theory test for permission to drive in NZ will be further required for the overseas driver who is likely to be considered a high-risk and holding an international driving licence (or driving permit).

Adverse weather conditions may affect driver behaviour and increase the potential risk of road accidents. Therefore, weather forecasts could be more frequent on the radio or media to warn drivers of cases of a heavy rain or snow. Other mitigation measures include installation of rumble strip or road barriers in those areas with multiple crash occurrences made by overseas drivers; multilingual road signs and markings to provide better guidance. However, the costs of such measures could be high.

It is recommended that a future study investigate the feasibility of large-scale improvements. A similar survey to be undertaken all year round in various locations of NZ would be advantageous in gaining more understanding of the driving challenges overseas drivers faced in NZ. Throughout this study, limitations have been encountered such as the limited budget for data sample collection and limited access to crash information due to the privacy policy. The CAS database provided by the New Zealand Transport Agency has no indication the responsibility of any of the involved parties. The peak travelling season for NZ is between December and February, yet the survey was done in October which may have limited the size of the survey sample.

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