ROAD SAFETY STUDY IN NEW ZEALAND:

ROAD CRASHES INVOLVING OVERSEAS DRIVERS

Author:

Yuxin (David) Zhang, BE, Waipa District Council,

david.zhang@waipadc.govt.nz

Hyun-Chan Kim, PhD, Waikato Institute of Technology,

chan.kim@wintec.ac.nz

Presenter:

Yuxin Zhang and Hyun-Chan Kim

ABSTRACT

The study explores the driving behaviour of overseas drivers and identifies the key causes contributing to road crashes in New Zealand (NZ) related to demographic and socio-economic characteristics of overseas drivers. A revealed preference (RP) study of 205 overseas drivers has been used to investigate whether overseas drivers' characteristics affected their ranked preference for attributes related to the risk of driving in NZ. The RP study and rank-ordered logistics regression models have been used to identify the importance of various factors in determining the causes of crashes and providing some insights into issues that should be considered accident reduction policy development. The results indicate that roundabouts are rare in some Asian countries and thus confusing to Asian drivers; mountainous roads are considered the most difficult terrain to drive on. The results further indicate that fatigue has a moderate impact on the drivers, with those aged above 30 tending to believe that fatigue affects subsequent driving performance. The results are consistent with the historical data from 2,328 crashes related to overseas drivers from 2010 to 2014 as extracted from the Crash Analysis System. Finally, the results of this study indicate that 'tailored' programmes to educate overseas drivers would be more effective than current practices and guidelines.

Keywords: accident, oversea drivers, rank-ordered logit model, New Zealand

INTRODUCTION

It is common that foreign visitors prefer to drive a vehicle when travelling around 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 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 (SNZ) 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 survey participants' perception of driving in NZ. A survey sample was made up of foreign visitors, international students and migrants. During the survey data analysis, the respondents were split into different groups based on each individual's socio-demographic information listed below:

- Gender
- Age
- Country of origin
- Driving experience in country of origin and in NZ
- Duration of visit in NZ
- Purpose of visit
- Ownership of the vehicle used in NZ

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.

NEW ZEALAND ROAD ACCIDENT: CRASH ANALYSIS SYSTEM

According to the data extracted from the CAS from 2010 to 2014, a total of 159,067 road crashes recorded in 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 below 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.

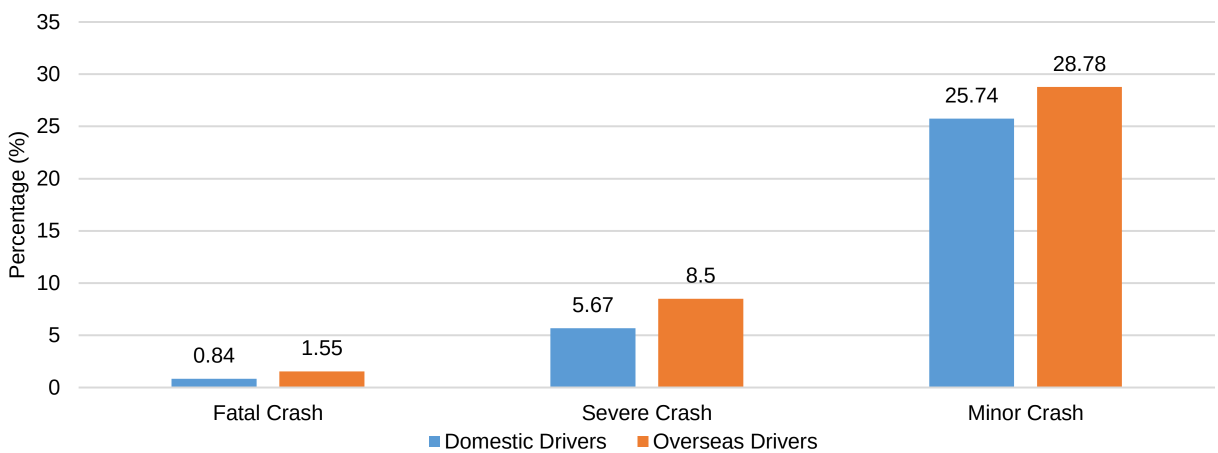

Figure 1. Crash comparison between domestic and overseas drivers

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 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.

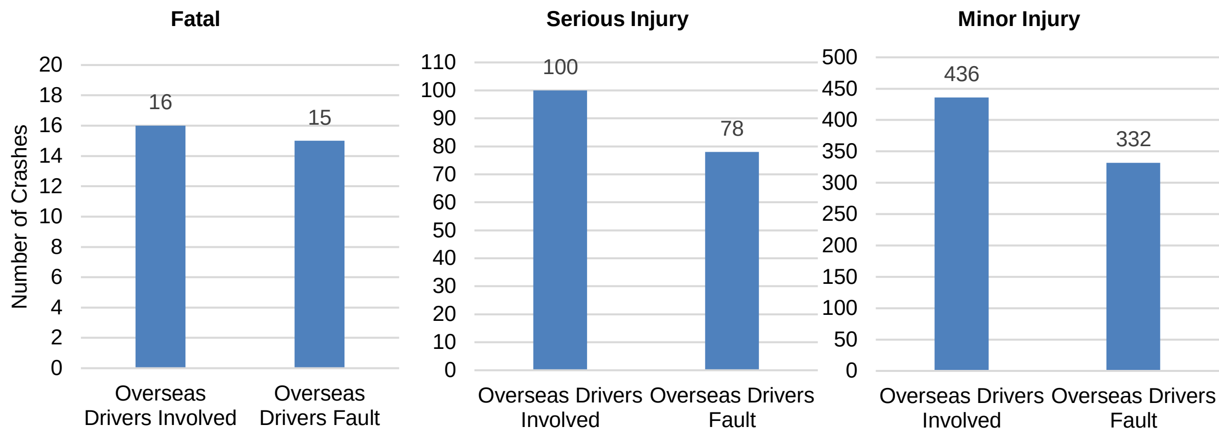

Figure 2. Party accountable for crashes

It has been reported that drivers coming from left-hand driving countries failed to adjust to NZ's right hand driving rules. 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 NZTA, there is no indication as to which party was responsible for driving on the incorrect side of the road.

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 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.

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

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 shows 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.

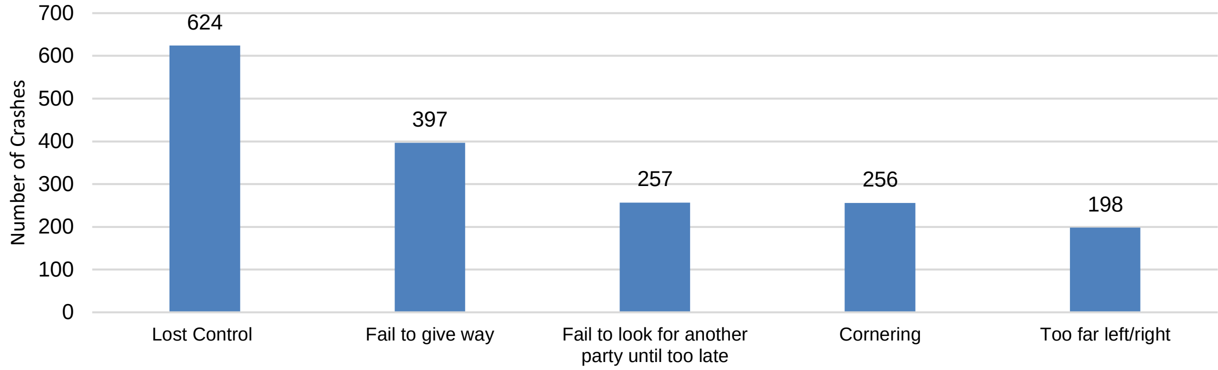

Figure 3. Top 5 contributory factors to crashes by domestic drivers

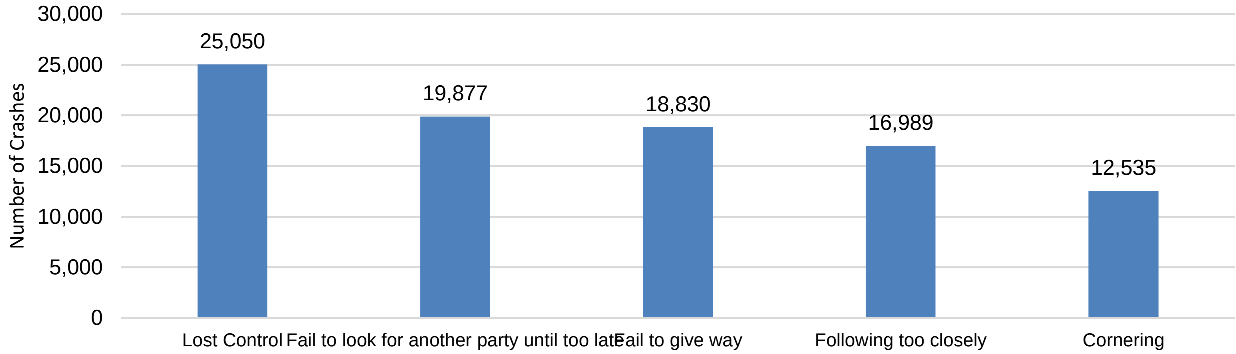

Figure 4. Top 5 contributory factors to crashes by overseas drivers

RANK-ORDERED LOGIT MODEL

The Rank Ordered Logit (ROL) Model is extended from the conditional logit regression model introduced by McFadden (1974), that was further 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), 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 et al., (2014) and Kim and Nicholson (2013) 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

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

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

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

When the first choice has been made, the second most preferred item can be chosen from the remaining (J − 1) items. The probability of item *j* being the second most preferred item is

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

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

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

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

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

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

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

The ROL model was used to analyse the statistical data collected from the revealed preference survey. The ROL model is used to analyse the preferences of individuals over a set of alternatives, where preferences are partially observed through 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. Consequently, 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, the 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 can be made between every other factor and 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 the statistical software SAS®. This approach is also found in Asch et al., (1999), Allison (1999), Lim (2002), Kumar and Kant (2007), Zhang et al., (2010), Kim et al., (2014), and Kim and Nicholson (2013). Allison and Christakis (1994) provide detailed discussion on exploiting identities in the likelihoods between the proportional hazards model and the ROL model by using the maximum likelihood procedure in SAS®.

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 et al., 2014; Kim and Nicholson, 2013).

The first task was to develop a model that allowed for differences between four driving factors but no differences among respondents. It was assumed that every respondent in the study had the same probability distributions for the driving factors and that the observed differences in the rankings were due only to random variation. This can be formulated as $V_{ij} = \beta_j x_i$ for all i and j, where β_j is used to capture the differences in log odds of ranking factor j ahead of the reference factor (Beggs et al., 1981).

Note that one of the four factors must be set as a reference (base factor) for achieving identification in the model. Thereby, each of the remaining β_j can be interpreted as the effect of a one-unit change in the explanatory variable on the log odds. Exponentiation of the β_j estimate yields the effect of the survey respondent's characteristic variable on the relative preference for factor j over the reference factor. Similarly, the percent change in odds ratio of ranking factor j ahead of the reference factor can be obtained by computing $100\left(e^{\beta_j} - 1\right)$.

One more feature of the ROL model is that the results are reflective. This means when the survey sample is put into two groups (e.g. male and female) for analysis, and the coefficient of one specific group (e.g. male) has been examined, the percentage change in the odds in preferring the factor over the other group (e.g. female) can be calculated by using the exponent of coefficient.

Data Analysis

For this study, the targeted survey participants were individuals driving in 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. 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.

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

RANK-ORDERED LOGIT ANALYSES FOR THE KEY CAUSES CONTRIBUTING TO THE ROAD CRASHES BY OVERSEAS DRVIERS

Perceived Causes of Road Crashes

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 regards 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 question 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	Wald χ^2
Overall	Road terrain (base)	0.000	0.000	1.000	2.42	0.000
	Road user rule	*-0.202	0.251	0.817	2.68	0.135
	Weather	0.056	0.254	1.057	2.40	2.100
	Fatigue	-0.096	0.255	0.908	2.51	2.947

***p<0.01. **p<.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 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	Wald χ^2
Road terrain	Highway (base)	0.000	0.000	1.000	2.80	0.000
	Rural roads	***0.419	0.125	1.520	2.44	11.301
	Mountainous roads	***0.874	0.130	2.397	1.96	45.067
	City centre	-0.036	0.128	0.947	2.80	0.080
Road user rules	Give way (base)	0.000	0.000	1.000	2.51	0.000
	Stop sign	-0.133	0.122	0.875	2.60	1.181
	Roundabout	***0.420	0.124	1.522	2.07	11.352
	Keep left	***-0.342	0.128	0.710	2.81	7.141
Weather	Drizzle (base)	0.000	0.000	1.000	3.83	0.000
	Fog	***1.152	0.129	3.164	2.54	79.193
	Heavy Rain	***1.326	0.133	3.767	2.35	99.308
	Snow	***0.527	0.128	1.694	3.22	16.779
	Sunstrike	***0.691	0.129	2.000	3.02	28.459

***p<0.01. **p<.05. *p<0.10

Again, the overall rank order results are largely consistent with the mean ranks. Table 5 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 3.78 times the chance of being chosen than drizzle, followed by fog (3.16 times), sunstrike (2 times) and snow (1.694 times).

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):

$$U_{ij} = (\beta_{terrain}x_{terrain} + \beta_{rule}x_{rule} + \beta_{weather}x_{weather} + \beta_{fatigue}x_{fatigue}) + \left(\beta_{age_{terrain}}x_{age_{terrain}} + \beta_{age_{rule}}x_{age_{rule}} + \beta_{age_{weather}}x_{age_{weather}} + \beta_{age_{fatigue}}x_{age_{fatigue}}\right)$$

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 the 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 New Zealand

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 in regard to 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 is 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. 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.

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<.05. *p<0.10

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 revelaed 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 is the most difficult sub-factor for driving. In terms of NZ road user rules, roundabouts has been revealed to be the most difficult sub-factor, while keep left has a lower level of complication for the respondents. Heavy rain has been revealed as the most favourable option for weather condition, followed by fog, sunstrike, snow and drizzle. If fatigue has shown a moderate impact on drivers. The results from most of the in-depth analysis with various socio-demographic groups has shown consistency to 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 suggests 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 with regard to the road conditions, 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. Weather forecasts could be more frequent on radio to warn drivers of cases of a heavy rain or snow. Other mitigation measures include installation of rumble strip/ road barriers in those areas with multiple crash occurrences; multilingual road signs and markings to provide better guidance; a compulsory theory test for permission to drive in NZ for people holding international driving licences or driving permits. However, the costs of such measures could be high. It is recommended that a future study to investigate the feasibility of large-scale improvements. A similar survey to be undertaken all year around 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 limited budget for data sample collection and limited access to crash information due to the privacy policy. The CAS database provided by the NZTA 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.

REFERENCES

Ahn J, Lee J, Lee J.D., Kim T.Y. (2006). An analysis of consumer preferences among wireless LAN and mobile Internet services. ETRI Journal 28: 205–215.

Alava, M. H., Brazier, J., Rowen, D., and Tsuchiya, A. (2013). Common Scale Valuations across Different Preference-Based Measures Estimation Using Rank Data. Medical Decision Making.

Allison, P. D. and Christakis, N. (1994), Logit models for sets of ranked items. Sociological Methodology, 24,199-228

Allison, P. D. (1999). Comparing logit and probit coefficients across groups. Sociological methods and research, 28(2), 186-208.

Asch, D. A., Faber-Langendoen, K., Shea, J. A., and Christakis, N. A. (1999). The sequence of withdrawing life-sustaining treatment from patients. The American journal of medicine, 107(2), 153-156.

Bishop, R. C. and Provencher, B. (2004) Does accounting for preference heterogeneity improve the forecasting of a random utility model? A case study, Journal of Environmental Economics and Management, 48,793–810.

Bouffioux, C., M. Beuthe and T. Pauwels, (2006), La Qualité des Services de Transport de Marchandises: Une Analyse Agrégée des Ordres de Préférences Déclarés. Les Cahiers Scientifiques du Transport N° 50, p. 135-138

Byfield, J. (2015). NZ Transport Agency: Visitor driver crash reduction study. Retrieved from: http://www.saferjourneys.govt.nz/assets/Otago-Southland-and-Westland-Visitor-driver-crash-reduction-study.pdf

Calfee, J., C. Winston, and Stempski, R. (2001), Econometric Issues in Estimating Consumer Preferences from Stated Preference Data: A Case Study of the Value of Auto Mobile Travel Time, The Review of Economics and Statistics, 83, 699-707.

Chapman, R.G. and Staelin, R. (1982), Exploiting rank ordered choice set data within the stochastic utility model. Journal of Marketing Research, 14, 288-301.

Clarkson, D. (2015). German tourist admits fatal Canterbury crash. Retrieved from: http://www.stuff.co.nz/the-press/news

Cox, P. R. (1972). Life Tables. John Wiley & Sons, Inc.

Cox, D. R., and Oakes, D. (1984). Analysis of survival data (Vol. 21). CRC Press.

Dagsvik JK, Liu G. (2006). A framework for analyzing rank ordered panel data with application to automobile demand. Discussion Papers 480, Research Department of Statistics Norway.

Drewes T, Michael C. (2006). How do students choose a university? An analysis of applications to universities in Ontario, Canada. Research in Higher Education 47: 781–800.

Driving School Ireland. (2013). Rules of the road. Retrieved from: http://www.drivingschoolireland.com/regulatory-signs.html

Hausman, J.A. and Ruud, P.A. (1987), Specifying and testing econometric models from rank-ordered data, Journal of Econometrics, 34, 83-104

Hsieh C. (2005). Age and relative importance of major life domains. Journal of Aging Studies 19: 503–512.

Kim, H.C. (2015) Foreign Travellers' Driving Behaviour and Crash Patterns: Finding from CAS database, IPENZ NZMUGS Conference, Auckland, New Zealand, September 2015.

Kim, H.C., and Nicholson, A.J., (2013) Freight Transport Modal Shift in NZ: Building Understanding of Shippers' Mode Choice based on RP/ SP surveys. IPENZ Transportation Group 2013 Conference, Dunedin, New Zealand, April 2013, 15 p.

Kim, H.C., Nicholson, A.J., and Kusumastuti, D. (2014) Book Chapter: Ch7. Determinants of Mode Choice and Modal Shift in New Zealand Freight Transport, in Sustainable Logistics (Transport and Sustainability, Volume 6), ISBN: 978-1-78441-062-9, Emerald Group Publishing Limited.

Koop, G., and Poirier DJ. (1994). Rank-ordered logit models: an empirical analysis of Ontario voter preferences. Journal of Applied Econometrics 9: 369–388.

Kumar, S., and Kant, S. (2007). Exploded logit modeling of stakeholders' preferences for multiple forest values. Forest policy and economics, 9(5), 516-526.

Lemanske Jr, R. F., Mauger, D. T., Sorkness, C. A., Jackson, D. J., Boehmer, S. J., Martinez, F. D., and Taussig, L. M. (2010). Step-up therapy for children with uncontrolled asthma receiving inhaled corticosteroids. New England Journal of Medicine, 362(11), 975-985.

Lim, N. (2002). Who Has More Soft-skills?: Employers' Subjective Ratings of Work Qualities of Racial and Ethnic Groups. RAND.

Mark DR, Lusk JL, Scott Daniel M. (2004). Recruiting agricultural economics graduate students: student demand for program attributes. American Journal of Agricultural Economics 86: 175–184.

Marvin, F. (2015). Queenstown rental firm tests foreign drivers. Retrieved from: http://www.scene.co.nz/queenstown-rental-firm-tests-foreign-drivers/321710a1.page

Massey, R. (2015). Motorway accidents involving foreign lorries have soared by 14 percent – with Polish drivers topping the crash league table. Retrieved from: http://www.dailymail.co.uk/news

McFadden, D. (1974), Conditional logit analysis of qualitative choice behavior, In: Zarembka, P. (Ed.), Frontiers in Econometrics. Academic Press, New York, pp. 105-142.

Millward, D. (2008). EU laws to stop UK Government from making foreign lorries carry safety mirrors. Retrieved from: http://www.telegraph.co.uk/news

Ministry of Transport. (2014). Fatigue. Retrieved from http://www.transport.govt.nz/assets/Uploads/Research/Documents/Fatigue-2014.pdf

Ministry of Transport. (2015). Overseas Driver Crashes, Retrieved from http://www.transport.govt.nz/assets/Uploads/Research/Documents/Overseas-drivers2015-15Jun15.pdf

Punj, G. N., and Staelin, R. (1978). The Choice Process for Graduate Business Schools. Journal of Marketing Research (JMR), 15(4).

Roberts, C. (2015). Make roads safer without test for foreign drivers. Retrieved from: http://www.nzherald.co.nz/business/news/article.cfm?c_id=3&objectid=11407892

Srinivasan, S., Bhat, C.R. and Holguin-Veras, J. (2006), Empirical analysis of the impact of security perception on intercity mode choice. A panel rank-ordered mixed logit model, Transportation Research Record, Vol. 1942, pp. 9-15.

Van Beek KWH, Koopmans CC, van Praag BMS. (1997). Shopping at the labour market: a real tale of fiction. European Economic Review 41: 295–317.

Van Dijk, B., Fok, D., and Paap, R. (2007). A Rank-Ordered Logit Model with Unobserved Heterogeneity. Ranking Capabilities, Econometric Institute Report.

Van Ophem H, Stam P, van Praag B. (1999). Multichoice logit: modeling incomplete preference rankings of classical concerts. Journal of Business and Economic Statistics 17: 117–128.

Wilson, C. (2014). Research to focus on tourist drivers. Retrieved from: http://www.radionz.co.nz/news/national/246095/research-to-focus-on-tourist-drivers

Wilson, M. (2004). Government terrified of testing foreign drivers, says campaigner. Retrieved from http://www.dogandlemon.com/media/government-terrified-of-testing-foreign-drivers-says-campaigner

Young, R. (2014).'Gorgeous' girls killed in car crash. Retrieved from: http://www.stuff.co.nz/the-press/news/10110212/Gorgeous-girls-killed-in-car-crash

Zhang, Z., Guan, H., Qin, H., and Xue, Y. (2013). A Traffic Mode Choice Model for the Bus User Groups based on SP and RP Data. Procedia-Social and Behavioral Sciences, 96, 382-389.