Effects of driver nationality and road characteristics on accident fault risk

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Abstract
This paper investigates the combined effect of driver nationality and several road characteristics (area type, at or not at junction, lighting conditions) on accident fault risk. Data from the national accident database of Greece are used to calculate accident relative fault risk rates under induced exposure assumptions. A log-linear analysis is then used to examine first- and higher-order effects within three or more variables groups. The examination of the second-order interaction among the accident fault risks of various driver nationalities at or not at junction was found to be significant. On the contrary, the respective combined effects of area type and lighting conditions were found to be non-significant. It was also shown that roadway features do not affect accidents fault risk in a combined way. Results clearly indicate that foreign drivers in Greece are at increased risk. Moreover, foreign nationalities corresponding to permanent residents (i.e. Greeks and Albanians) appear to be at lower fault risk compared to foreign nationalities corresponding to tourists and visitors (e.g. EU Nationals). The effects of the various road characteristics do not modify these general trends.

Key words: driver nationality, road characteristics, accident fault risk, log-linear models

1. Introduction

The relative higher accident risk foreign drivers may bear according to various studies is examined in the present study in relation to road infrastructure. Greece is chosen as a representative example of a country accommodating foreign drivers of different types. In particular, a considerable increase to the immigrants' population of Greece, (167.000 in 1991 census to 800.000 in 2001), mainly Albanians, added to the native population as permanent residents during the decade of 90's, as well as its popularity as a tourist destination, have led to the increase of the Greek road network users.

A relevant study in the Greek island of Corfu (Petridou et al., 1999), examines whether traffic injuries among foreign tourists are more common and severe. Based on hospital data, the study concludes that foreign drivers are at increased risk of traffic injuries in comparison with Greek drivers. Another study (Petridou et al., 1997) dealing with road traffic accidents and pleasure traveling in the Greek island of Crete suggest that foreign nationals from left-side driving countries had an increased risk of traffic accidents (2.5 times more than those from right-side driving countries) especially when they drove a rented rather than an owned car. Alcohol abuse was the primary cause in 22% of accident involving foreign drivers. It should be noted that these two studies investigate the road safety of tourists and visitors in Greece, whereas no relevant research is available on immigrant permanent residents.

In general, there are several studies, which focus on road safety issues of foreign and local drivers in the same country. Quddus et al. (2002) examined factors that affect injury severity in motorcycle accidents and found that foreign drivers have increased probability of severe injury. Another study (Dissanayake, Lu, 2001) concludes that most international drivers lack understanding of traffic control devices, signals and markings in relation to local drivers. Moreover, another study reveals that Russian drivers in southeastern Finland have higher accident risk compared to Finnish drivers (Leviakangas, 1998).

Other studies focus on road safety attitude and driving behavior issues. A study on driving behavior (Koushki et al., 1998) related seat belt use with factors such as nationality, age, gender, road type, vehicle type, trip time and distance, and concluded that foreign drivers have higher seat belt use rates and lower traffic violations rates. Another study investigates the behavior of American drivers in Europe resulting from the different signing policy at uncontrolled intersections (Summala, 1998) and the related effect on risk-taking crossing behavior. A similar study investigated risk-taking proneness among various Spanish and U.S drivers' categories by examining intersection gap acceptance (Soler, Sivak, 1987).

Previous research has indicated that foreign drivers (tourists and immigrants) are seemingly more vulnerable than the indigenous road users in accident involvement, mainly due to a lack of knowledge of the road network and of understanding local traffic rules. Moreover, insufficient driving skills and the variance of the general attitudes towards road safety, which are reflected in the driving behavior, are identified as some of the parameters that further contribute to the observed high accident risk of foreign drivers.

Most relevant studies focus on individual drivers characteristics, while the effect of roadway environment is less investigated. Aty and Radwan (1998) examined the role of demographic factors such as race, gender, age and residence on the relative risk of accident involvement at intersections, combining thus to some degree roadway and personal parameters. However, the different types of foreign users of the road infrastructure i.e. immigrant and tourist population, are not examined separately. Finally, only few studies focus on accident fault risk of foreign drivers.

2. Objectives and methodology

The objective of this paper concerns the investigation of accident fault risk of foreign and indigenous drivers in Greece in relation to roadway environment. More specifically, the extent to which the probability of provoking an accident is higher for foreign drivers (immigrants or tourists) compared to the indigenous' is examined, and the related effect of different infrastructure features on accident fault risk is quantified.

In particular, the following issues are examined:

- The distribution of accident fault risk by driver nationality
- The effect of several roadway environment characteristics on the distribution of accident fault risk
- The combined effect of different roadway environment characteristics on the distribution of accident fault risk.

On that purpose, a dataset extracted from the road accident database of the National Statistical Service of Greece is exploited. This database is the official accidents database of Greece and includes detailed disaggregate data for all road accidents with casualties reported by the Police. The quality of these data has been tested on several occasions, both by the control mechanisms of these authorities and the researchers using them. The dataset used includes all drivers involved in two-vehicle injury road accidents on the road network of Greece in the period 1996-2001 as recorded by the Police. The categories of drivers examined include Greek drivers, drivers from EU countries (i.e. EU of 15 member states), drivers of other (than EU) nationality and Albanian drivers (i.e. the majority of immigrant permanent residents in Greece), those categories being representative of the population composition of Greece. The categories of accidents examined include accidents inside / outside urban areas, at or not at junctions and during daylight or night, those characteristics being chosen as the most representative of the road environment.

Due to the lack of respective exposure data, an induced exposure technique is applied, in order to calculate relative fault risk rates. A log-linear analysis is then applied, in order to estimate the magnitude and statistical significance of single and combined variable effects on the relative fault risk rates.

The induced exposure technique is based on the assumption that in every road accident, in which two vehicles are involved, there is one driver responsible for the accident and one innocent driver involved, selected at random from the total population of drivers. Consequently, the innocent driver can be considered as a sample of the total population of drivers and reflects the exposure of any specific driver population defined on the basis of certain characteristics (Haight, 1973, Hodge, Richardson, 1985). The induced exposure technique has been widely examined in international literature and was found to be promising for determining relative at-fault accident rates in which not-at-fault accidents serve as an indicator of exposure under specific conditions. One of the most important features of this technique is the fact that it allows for disaggregate fault risk analysis to the level of disaggregation of the accident data (Golias, Yannis, 2001). On the other hand, the identification of the driver who provoked the accident is required; in Greece, this driver is identified by the Police and the related information is included in the data collection. Additionally, the use of this method in single vehicle accidents is not recommended (Evans 1990) and consequently only two-vehicle accidents are considered in the present analysis.

Fault risk rates were calculated under the induced exposure assumptions. However, it would be difficult to extract any conclusions through the direct comparison of accident fault rates, especially when effects are examined separately. In order to identify the degree of consistency and / or validity of results and investigate the significance of all possible single and combined effects, a log-linear analysis was applied on the aggregate fault risk rates. A stepwise approach was adopted as far as the effect of roadway characteristics are concerned; more specifically, single roadway environment variables were at first entered in the analysis, and then combined roadway effects were examined.

The log-linear analysis technique concerns an additive model incorporating single effects and interactions between variables (e.g. in the case of three variables 1: accident fault, 2: driver nationality and 3: area type) in the following form:

$$\text{Log } F_{ijk} = u + u_{1(i)} + u_{2(j)} + u_{3(k)} + u_{12(ij)} + u_{13(ik)} + u_{23(jk)} + u_{123(ijk)}$$

Where F_{ijk} are the expected cell frequencies and u are parameters to be estimated under Poisson assumptions. The above formula for a three-dimensional Table corresponds to a saturated log-linear model, containing all possible three-way and lower order effects. Moreover, the models considered are hierarchical, in the sense that whenever a higher order effect is included in the model, the lower order effects composed from variables in the higher effect are also included (Everitt, 1977, Kim et al., 1998).

Therefore, a three-dimensional Table of i rows, j columns and k layers can be disaggregated into row effects, column effects, layer effects and their interactions ($i\times j$, $j\times k$, $i\times k$ and $i\times j\times k$). The second-order interaction ($i\times j\times k$) is the most interesting since, if this value is significant, then there is a significant interaction among all examined effects. If (and only if) not, then the separate effects can be further analysed and interpreted (Goodman, 1973). The hypotheses of the analysis are those of mutual independence, i.e. the analysis assumes that there are no first-order interactions between any pair of variables and no combined three-variable interaction:

$$H_0: u_{12}=0, u_{13}=0, u_{23}=0, u_{123}=0$$

Main effect parameters are measured as deviations of row, column or layer means of log-frequencies from the overall mean. Each of the u parameters represents a deviation from the grand mean due to that effect (Hays, 1981). For example, $u_{1(j)}$ are single variable effects with a separate parameter estimate for each value. The term $u_{12(ij)}$ represents the interaction between two variables with a separate parameter estimate for each pair of values. Estimates of the parameters in the fitted model are obtained as functions of the logarithms of cell frequencies of the Table representing the aggregate data, and the form of these estimates is similar to those used for the parameters in analysis of variance models. The parameter estimates and their statistical significance are determined on the basis of the best-fitting log-linear model (Everitt, 1977).

3. Results

3.1. Relative accident fault risk of foreign and indigenous drivers

Table 1 presents the accident fault risk distribution within the four nationality categories as calculated by the use of the induced exposure method. The first two rows concern the fault frequencies per driver category. It is noted that the slight difference in the total frequencies between at-fault and not-at-fault are due to the different proportion of "unknown" nationality in the two categories. The following rows concern the fault risk rates per nationality category and their confidence intervals. The relative fault risk on the bottom row is derived as the normalization of the separate accident fault risk results (i.e. divided by the lowest accident risk per category), indicating the higher percentage of accident fault risk in comparison to the nationality category with the lowest accident fault risk. The confidence intervals of the relative risk rates were calculated for 95% level of significance.

Table 1 to be inserted here

The accident fault risk breakdown reveals that Greeks have lower fault risk than all foreign drivers; a 0.98 ratio is calculated, suggesting that in the examined category they cause fewer accidents than the ones they get caught into.

Among the three other categories of foreign drivers, the drivers of other (than Albanian and EU) nationality appear to have higher accident risk than the rest two categories. Additionally, Albanians (i.e. mainly permanent residents) appear to be at lower fault risk compared to EU Nationals (i.e. mainly tourists).

3.2. The effect of area type

Table 2 presents the normalized accident fault risk distribution per driver nationality and area type (inside / outside urban area). Accident fault risk for Greek drivers remains lower both inside and outside urban areas in relation to the rest three nationality categories. Drivers with other nationality bear in all cases the highest accident risk. However, it is interesting to note that that there is no significant difference between drivers from EU and Albania outside urban area, as indicated by the significant degree of overlap between the respective confidence intervals of the fault risk rates. On the other hand, a difference in drivers fault risk between inside and outside urban area can only be identified for EU nationals.

Table 2 to be inserted here

However, these initial suggestions are only indicative of some general trends. In order to verify the significance of the relative fault risk rates and investigate interactions between variables, a log-linear model was fitted to the fault frequency data. Accident fault risk is expressed as a binary variable (at-fault / not at-fault). The parameters estimated and the related levels of statistical significance are presented in Table 3. It should be also noted that the parameter estimates are in fact estimated log-odds ratios, corresponding to the risk rates observed in Table 2.

It is quite interesting to notice that no second-order interaction between accident fault risk, driver nationality and area type was identified (chi-square value for this effect is equal to 5.5 which is non significant for 3 degrees of freedom). On the other hand, first-order effects present an important overall significance, with a chi-square value equal to 207.2 for 10 degrees of freedom.

Table 3 to be inserted here

The lack of second-order interaction implies that (a) the interaction between accident fault and driver nationality is the same at all area types, and (b) the interaction between accident fault and area type is the same for all driver nationality categories. It is obvious that area type has no direct significant effect on accident fault risk. However, it is strongly related to driver nationality, indicating a significantly different presence of different nationalities inside / outside urban areas. This can be further explained as follows: even if all drivers drove in the same area type, the differences in accident fault by driver nationality would be significant. In fact though, not all drivers drive in the same area type, because the area type is associated with driver nationality. For example, EU nationals (i.e. mostly tourists or visitors) may drive more outside urban areas than Albanians (i.e. mostly permanent residents)

3.3. The effect of junctions

Table 4 presents the accident fault risk distribution per driver nationality and junction (at junction / not at junction). Again, in all cases Greek drivers present the lowest accident fault risk and drivers of "other" (than EU and Albanian) nationalities present the highest accident risk. In this case, however, Albanians appear to have better figures at junctions than the rest two categories of foreign drivers, as their risk confidence intervals present no overlap in this case. On the contrary, the fault risk of Albanians can not be distinguished from the fault risk of EU nationals outside junctions. It is interesting to notice, though, that EU and "other" nationalities present significantly different accident fault risk at and not at junctions, at least as indicated from the confidence intervals of the risk rates.

Table 4 to be inserted here

A log-linear model was fitted to the accident fault frequencies of the different nationalities at and not at junction. The parameters estimated and the related levels of statistical significance are presented in Table 5. In this case, the backward stepwise procedure rejected none of the effects, revealing that the saturated model is the best-fitting model for describing the structural relationship between the three variables.

The second order interaction (fault risk*nationality*junction) was found to be significant with a chi-square likelihood ratio of 10 with 3 degrees of freedom. However, it is quite interesting to notice that this overall significance arises from the significance of only one particular effect, the one concerning the accident fault of the Greek drivers at junctions (significantly lower compared to the rest three nationalities).

As expected from the hierarchical modelling, all two-way effects were found to be statistically significant with a chi-square value of 148.4 with 10 degrees of freedom. As shown in Table 5, the overall significance of both nationality and junction effects on accident fault risk arises from the significance of almost all the sub-categories effects.

Table 5 to be inserted here

The above results indicate that there is a significantly different distribution of accident fault risk per driver nationality at junctions and not at junctions. In particular, not only junctions affect significantly accident fault risk, but also the significantly different presence of different nationalities at or not at junctions further differentiates the fault risk distribution.

3.4. The effect of lighting conditions

Table 6 presents the accident fault risk distribution per driver nationality and lighting conditions (daylight / night). No conclusions can be drawn from the calculated fault risk rates of non Greek drivers as far as the effect of lighting conditions is concerned, as there is a significant degree of overlap among the confidence intervals of all foreign drivers risks. Greek and Albanian drivers seem to have better figures at night compared to the EU and "other" nationalities; however this can not be validated from the confidence intervals of the fault risk rates.

The results of this category do not confirm the initial suspicion that the additional difficulty added by night lighting conditions adds to the accident fault risk of drivers who are unfamiliar with the road infrastructure.

Table 6 to be inserted here

The log-linear model fitted to the fault frequencies per driver nationality and lighting conditions confirmed the initial results presented above. No second-order interaction between accident fault risk, driver nationality and lighting conditions was identified (chi-square value for this effect is equal to 2.7 which is non significant for 3 degrees of freedom). The first-order effects present an overall chi-square value equal to 115.3 for 10 degrees of freedom; however, the backward stepwise analysis rejected the fault risk*lighting conditions effect, resulting in a best-fitting model including only two first-order effects (fault risk*nationality and nationality*lighting conditions), as shown in Table 7.

*** Table 7 to be inserted here ***

The fact that the single effect of night lighting conditions is not significant can not fully explain the lack of second-order interaction in the model. However, the fact that the combined effect of driver nationality and lighting conditions is significant confirms a significantly different presence of driver nationalities at during daylight or night. More specifically, EU and "other" nationalities are less likely to drive during the night, compared to Greeks and Albanians. Nevertheless, driver nationality itself (and the related consequences on knowledge and understanding of the road network) appears to be a more important factor on fault risk than lighting conditions.

3.5. Combined effects of roadway environment

The final stage of the present analysis concerns the investigation of combined roadway environment effects. In Table 8, the results of the hierarchical log-linear analysis are presented, including all five variables. The top part of the Table shows the parameter estimates and their significance for the detailed effects and the bottom part of the Table shows the results of the chi-square tests for the overall K-order effects.

Table 8 to be inserted here

It is noticed that the highest order significant effect concerns the interaction fault*nationality*junction (i.e. Greek drivers have significantly lower fault risk compared to the other nationalities). Moreover, the related effects of the other roadway elements (i.e. fault*nation*area and fault*nation*light) are not significant in the final model, although they were significant when examined separately. This can be explained when examining the effects concerning the combinations environmental factors, in which some correlations among the factors are revealed. It can be said that, due to these correlations, the effect of junctions includes (and maybe also outperforms) the effect of the other environmental factors, when they are all examined jointly.

Furthermore, no third- or fourth-order interaction between variables was found to be significant, i.e. roadway characteristics do not influence accident fault risk in a combined way. In the hierarchical 5-way analysis (see bottom of Table 8), the overall second order effect (i.e. all combinations of three variables) was not found to be significant; in particular, it appears that the significant effect of accident fault*nationality*junction does not account itself for overall significance of all 3-way effects.

4. Discussion

This research analyzed the accident fault proneness of foreign drivers in Greece in relation to road infrastructure elements. Area type, junctions, and lighting conditions are three road environment elements among the prevailing ones, which were examined to determine accident risk. Data elaboration was carried out through the use of the induced exposure method. Log-linear analysis allowed for the quantification of single and combined effects of roadway features on the accident fault risk of four different nationality categories, namely Greeks (i.e. indigenous drivers), Albanians (i.e. the majority of immigrant permanent residents, EU Nationals (mainly visitors and tourists) and other nationalities, this categorization being representative of the composition of the drivers population in Greece.

Results indicated that there is indeed an increased accident fault risk for drivers of foreign nationality. However, EU and other nationalities appear to be by far more vulnerable compared to Albanians, regardless of the road environment. It could be deduced that, the greater the geographical distance, the poorer the perception of road safety. Another possible influence on this general trend could be the gap of socioeconomic characteristics (Al Madani et al., 2000). However, the persistently high accident risk ratios for foreign drivers are most probably suggestive of an inadequate behavior. It can be said that Greek drivers are significantly more familiar with the complexity of the road infrastructure in Greece, which is partly due to the complex greek relief and partly due to some deficiencies of the road infrastructure, the traffic conditions and the prevailing driving behavior, and this natural adaptation helps to a better response to accident fault risk. Moreover, Albanians, being mostly permanent residents, may adopt a more conservative driving behavior (e.g. they do not wish to break the rules of the host country) than the other foreign drivers, corresponding mostly to pleasure travelers, resulting in a lower accident fault risk.

The road infrastructure elements that appear to be connected with the generally higher accident risk of foreign drivers are junctions; on the contrary, area type and lighting conditions do not seem to differentiate accident fault risks to a degree for further investigation. Nevertheless, there was evidence that the various road infrastructure features are correlated and this may be a factor explaining the limited influence of some of these road features on accident fault risk.

The significant effect of junctions can be explained as follows: junctions are a complex part of the road infrastructure, yet present in all road environments (i.e. in all road and area types) and thus frequently used by all road users, occasional or permanent. The combination of decisions to be taken when approaching junctions, whose layout is not familiar to foreign drivers, and the increased maneuvering involved, further complicated by the more demanding traffic rules, may be seen as some of the reasons for an increased fault risk of foreign drivers. Moreover, the seasonality and occasional use of junctions by EU and other nationality foreign drivers may render them more vulnerable to accident risk than Albanians. Signalization, priority or construction issues are factors that may further influence accidents at junctions and there are studies (Summala, 1998) connecting them with foreign drivers behavior.

Following the above, it can be deduced that foreign drivers are on the track of a different driving behavior, which can be more or less adequate than the one of their own country. A poor knowledge of the local traffic rules, often related with the educational or financial level of the foreign driver, may also be equally important. In general, various demographic, infrastructure and behavioral parameters can be considered to account for the increased accident risk of foreign drivers and determine related countermeasures. The present research focused on the effect of road environment and on the investigation of different groups of foreign drivers.

Further research would be required in order to quantify the role of other specific features of the environment and the infrastructure, aiming at identifying specific design and signalization requirements for foreign drivers. It should be also noted that different types of foreign drivers should be examined in more detail. For example, driving under the influence of alcohol, foreign truck drivers, use of mopeds by tourists, may constitute additional high risk situations and should be treated accordingly.

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Table 1. Accident fault risk distribution per driver nationality

	Greek		Albanian		EU		Other		Total
At-fault	16,084		336		274		453		17,147
Not at-fault	16,325		263		201		259		17,048
Accident Risk	0.98		1.27		1.36		1.74		
Relative Risk	**1.00**		**1.30**		**1.38**		**1.78**		
Lower/Upper limit	0.98	1.02	1.19	1.40	1.25	1.51	1.64	1.91	

Table 2. Accident fault frequencies and risk distribution per driver nationality and area type (inside / outside urban areas)

At-fault	**Greek**		**Albanian**		**EU**		**Other**		**Total**
Inside Urban area	10,663		235		131		262		11,291
Outside Urban area	5421		101		143		191		5856
Not at-fault									
Inside Urban area	10,806		177		75		147		11,205
Outside Urban area	5519		86		126		112		5843
Relative Risk	**Greek**		**Albanian**		**EU**		**Other**		
Inside Urban area	**1.00**		**1.35**		**1.77**		**1.81**		
Lower/Upper limit	0.98	1.02	1.21	1.48	1.51	2.03	1.62	1.99	
Outside Urban area	**1.00**		**1.20**		**1.16**		**1.74**		
Lower/Upper limit	0.97	1.03	1.02	1.37	1.01	1.30	1.53	1.95	

Table 3. Log-linear analysis - Accident fault risk, driver nationality, area type (Model with no second order interaction)

Parameter				Coefficients	Z-Value	
FAULT*NATION*AREA	At-fault	Inside Urban Area	Greece	-0.036	-1.862	
			Albania	-0.006	-0.152	
			EU	0.070	1.818	
FAULT*NATION	At-fault		Greece	-0.145	-7.468	*
			Albania	-0.026	-0.700	
			EU	0.033	0.856	
FAULT*AREA	At-fault	Inside Urban Area		0.037	1.966	*
NATION*AREA		Inside Urban Area	Greece	0.157	8.056	*
			Albania	0.211	5.760	*
			EU	-0.331	-8.623	*
FAULT	At-fault			0.137	7.233	*
NATION			Greece	3.004	154.557	*
			Albania	-1.009	-27.588	*
			EU	-1.188	-30.912	*
AREA		Inside Urban Area		0.181	9.508	*

**indicates a significant effect*

Tests that K- and lower-order effects are zero

K	DF	Chi-square	Probability
3	3	5.478	0.140
2	10	207.165	0.000
1	15	80589.840	0.000

The final model has generating class FAULT*NATION, NATION*AREA, FAULT*AREA

Table 4. Accident fault frequencies and risk distribution per driver nationality and junction (at junction / not at junction)

At-fault	Greek		Albanian		EU		Other		Total
At junction	9,446		208		126		257		10,037
Not at junction	6638		128		148		196		7110
Not at-fault									
At junction	9,679		158		74		124		10,035
Not at junction	6646		105		127		135		7013
Relative Risk	**Greek**		**Albanian**		**EU**		**Other**		
At junction	**1.00**		**1.35**		**1.74**		**2.12**		
Lower/Upper limit	0.98	1.02	1.21	1.49	1.49	2.00	1.89	2.36	
Not at junction	**1.01**		**1.23**		**1.18**		**1.47**		
Lower/Upper limit	0.99	1.03	1.07	1.40	1.03	1.32	1.30	1.63	

Table 5. Log-linear analysis - Accident fault risk, driver nationality, at or not at junction (Model with second order interaction)

Parameter				Coefficients	Z-Value	
FAULT*NATION*JUNCTION	At-fault	At Junction	Greece	-0.054	-2.826	*
			Albania	-0.031	-0.878	
			EU	0.046	1.202	
FAULT*NATION	At-fault		Greece	-0.146	-7.626	*
			Albania	-0.019	-0.551	
			EU	0.031	0.818	
FAULT*JUNCTION	At-fault	At Junction		0.048	2.580	*
NATION*JUNCTION		At Junction	Greece	0.114	5.969	*
			Albania	0.153	4.345	*
			EU	-0.243	-6.329	*
FAULT	At-fault			0.139	7.456	*
NATION			Greece	3.020	158.248	*
			Albania	-0.982	-27.959	*
			EU	-1.214	-31.654	*
JUNCTION		At Junction		0.068	3.658	*

**indicates a significant effect*

Tests that K- and lower-order effects are zero

K	DF	Chi-square	Probability
3	3	10.039	0.018
2	10	148.368	0.000
1	15	78102.660	0.000

The final model has generating class FAULT*NATION*JUNCTION

Table 6. Accident fault frequencies and risk distribution per driver nationality and lighting conditions

At-fault	**Greek**		**Albanian**		**EU**		**Other**		**Total**
Daylight	9,438		186		190		279		10,093
Night	6646		150		84		174		7054
Not at-fault									
Daylight	9,627		141		150		150		10,068
Night	6698		122		51		109		6980
Relative Risk	**Greek**		**Albanian**		**EU**		**Other**		
Daylight	**1.00**		**1.35**		**1.29**		**1.90**		
Lower/Upper limit	0.98	1.02	1.19	1.50	1.15	1.43	1.70	2.09	
Night	**1.00**		**1.24**		**1.67**		**1.62**		
Lower/Upper limit	0.98	1.03	1.09	1.40	1.37	1.96	1.42	1.81	

Table 7. Log-linear analysis - Accident fault risk, driver nationality, lighting conditions (Model with no second order interaction)

Parameter				Coefficients	Z-Value	
FAULT*NATION*LIGHT	At-fault	Daylight	Greece	0.000	0.006	
			Albania	0.022	0.629	
			EU	-0.062	-1.487	
FAULT*NATION	At-fault		Greece	-0.149	-7.521	*
			Albania	-0.020	-0.570	
			EU	0.041	0.986	
FAULT*LIGHT	At-fault	Daylight		-0.003	-0.161	
NATION*LIGHT		Daylight	Greece	-0.056	-2.816	*
			Albania	-0.143	-4.087	*
			EU	0.237	5.716	*
FAULT	At-fault			0.142	7.322	*
NATION			Greece	3.041	153.842	*
			Albania	-0.941	-26.876	*
			EU	-1.282	-30.890	*
LIGHT		Daylight		0.234	12.087	*

**indicates a significant effect*

Tests that K- and lower-order effects are zero

K	DF	Chi-square	Probability
3	3	2.721	0.437
2	10	115.290	0.000
1	15	78133.799	0.000

The final model has generating class FAULT*NATION, NATION*LIGHT

Table 8. Log-linear analysis - Accident fault, nationality, area type, junction, lighting conditions

Parameter						Coefficient	Z-value
FAULT*LIGHT*JUNCTION*AREA*NATION	At-fault	Daylight	At junction	Inside Urban Area	Greece	-0.013	-0.559
					Albania	0.042	1.011
					EU	-0.015	-0.313
FAULT*LIGHT*JUNCTION*AREA	At-fault	Daylight	At junction	Inside Urban Area		0.012	0.526
FAULT*LIGHT*JUNCTION*NATION	At-fault	Daylight	At junction		Greece	0.008	0.332
					Albania	-0.049	-1.183
					EU	0.046	0.979
FAULT*LIGHT*AREA*NATION	At-fault	Daylight		Inside Urban Area	Greece	-0.003	-0.111
					Albania	-0.015	-0.359
					EU	0.032	0.694
FAULT*JUNCTION*AREA*NATION	At-fault		At junction	Inside Urban Area	Greece	-0.024	-1.054
					Albania	0.000	0.001
					EU	0.032	0.675
LIGHT*JUNCTION*AREA*NATION		Daylight	At junction	Inside Urban Area	Greece	-0.013	-0.560
					Albania	-0.063	-1.497
					EU	0.019	0.416
FAULT*LIGHT*JUNCTION	At-fault	Daylight	At junction			-0.006	-0.266
FAULT*LIGHT*AREA	At-fault	Daylight		Inside Urban Area		0.000	0.017
FAULT*JUNCTION*AREA	At-fault		At junction	Inside Urban Area		0.020	0.893
LIGHT*JUNCTION*AREA		Daylight	At junction	Inside Urban Area		0.015	0.685
FAULT*LIGHT*NATION	At-fault	Daylight			Greece	-0.004	-0.194
					Albania	0.009	0.215
					EU	-0.047	-1.000
FAULT*JUNCTION*NATION	At-fault		At junction		Greece	-0.043	-1.892 *
					Albania	-0.033	-0.793
					EU	0.005	0.106
LIGHT*JUNCTION*NATION		Daylight	At junction		Greece	0.005	0.240
					Albania	0.023	0.559
					EU	0.017	0.356
FAULT*AREA*NATION	At-fault			Inside Urban Area	Greece	-0.012	-0.523
					Albania	0.014	0.328
					EU	0.048	1.033
LIGHT*AREA*NATION		Daylight		Inside Urban Area	Greece	-0.006	-0.275
					Albania	0.066	1.588
					EU	-0.047	-1.013
JUNCTION*AREA*NATION			At junction	Inside Urban Area	Greece	-0.009	-0.406
					Albania	0.003	0.082
					EU	-0.021	-0.438
FAULT*LIGHT	At-fault	Daylight				0.003	0.113
FAULT*JUNCTION	At-fault		At junction			0.037	1.631
LIGHT*JUNCTION		Daylight	At junction			0.006	0.247
FAULT*AREA	At-fault			Inside Urban Area		0.016	0.734
LIGHT*AREA		Daylight		Inside Urban Area		-0.095	-4.226 *
JUNCTION*AREA			At junction	Inside Urban Area		0.498	22.178 *
FAULT*NATION	At-fault				Greece	-0.137	-5.985 *
					Albania	-0.031	-0.746
					EU	0.043	0.913
LIGHT*NATION		Daylight			Greece	-0.026	-1.140
					Albania	-0.118	-2.829 *
					EU	0.198	4.233 *
JUNCTION*NATION			At junction		Greece	0.055	2.406 *
					Albania	0.070	1.677 *
					EU	-0.123	-2.618 *
AREA*NATION				Inside Urban Area	Greece	0.125	5.449 *
					Albania	0.154	3.692 *
					EU	-0.246	-5.250 *
FAULT	At-fault					0.132	5.880 *
LIGHT		Daylight				0.236	10.510 *
JUNCTION			At junction			-0.015	-0.675
AREA				Inside Urban Area		0.214	9.528 *
NATION					Greece	3.021	131.695 *
					Albania	-0.970	-23.210 *
					EU	-1.243	-26.527 *

**indicates a significant effect*

Tests that K and lower order effects are zero

K	DF	Chi-square	Probability
5	3	1.247	0.7417
4	16	9.042	0.9117
3	38	32.716	0.712
2	56	7205.978	0
1	63	89731.323	0