TRA2020 – Rethinking transport
Towards clean and inclusive mobility • Helsinki 27–30 April 2020

Modelling the economic impacts of road crashes in Greece

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Abstract

This research aims to quantify the Willingness-To-Pay (WTP) attitude of the Greek public towards mitigating road crash risk and thus crash involvement in the macroscopic scale. An online questionnaire survey was designed and distributed to participant drivers. Two scenarios of WTP in order to reduce crash involvement probability were included: 20% and 50% reductions in probability; 238 valid responses were collected and analyzed. Ordinal and multinomial logistic regression models were used to correlate driver preferences between the two scenarios and several independent variables, in contrast with the do-nothing (0% reduction) scenario. Results indicated that most drivers are very positively predisposed towards a road crash risk reduction. The choice between low and high reductions depends on trip duration and cost increases, family situation, driving experience and annual family income. The calibrated WTP models are used in a case study to calculate the human cost (value of statistical life) in Greece during 2016.

Objective

- Estimation of the **human cost of road crashes** based on the WTP method
- Identification of **driver attitudes** towards the probability of being involved in a road crash

Data Collection

An online **questionnaire survey** was utilized by **238 participants** for the estimation of human cost, which consisted of four distinct sections:

- Driving experience
- Road crash perception and involvement
- Willingness to pay investigation
- Demographic questions

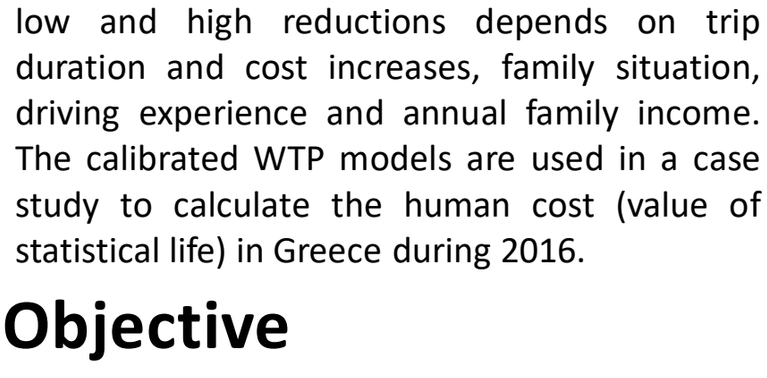

Figure 1. Gender distribution per age group of participant drivers

Methodology

Two modelling approaches were employed:

- **Ordinal logistic regression** for the occurrence probability of an event p, based on the assumption that the logarithms of odds follow an arithmetic series, can be expressed as follows:

$$y_i^* = logit(p) = \ln\left(\frac{p}{1-p}\right) = b_o + \sum b_i x_i \qquad (1)$$

- **Multinomial logistic regression** for N possible outcomes can be described as an array of N-1 independent binary regressions of the odds of an outcome compared to the previous one, as follows:

$$\hat{P} = \frac{e^{b_o + b_i x_i}}{\sum_n (e^{b_o + b_i x_i})} \qquad (2)$$

Modelling Results

Table 1. Ordinal logistic regression model results

Parameter	Variable – Relevant Question	Coefficient	Std. Error	Significance	Odds Ratio
Constant P_{1-2}		-5.308	0.838	0.000	–
Constant P_{2-3}		-3.776	0.794	0.000	–
Constant P_{3-4}		-2.180	0.766	0.004	–
NC0	Answers: 0, 1, >1 to the question "As a driver, how many road crashes have you involved in?"	-2.499	0.696	0.000	0.08
NC1		-2.086	0.733	0.004	0.12
NC2 (reference cat.)		–	–	–	–
FI1	Answers: <10,000€, 10,000-25,000€, 25,000-50,000€ and >50,000€ to the question "What was your annual household income last year?"	-1.566	0.522	0.003	0.21
FI2		0.772	0.487	0.113	-
FI3		-1.433	0.466	0.002	0.24
FI4 (reference cat.)		–	–	–	–
KD1	Answers: <10, 10-40 and 40-100 >100 to the question "Approximately how many kilometers do you drive per week?"	0.988	0.457	0.031	2.69
KD2		0.901	0.400	0.024	2.46
KD3		1.185	0.367	0.001	3.27
KD4 (reference cat.)		–	–	–	–

Acronyms: NC – Number of Crashes | FI – Family Income | KD – Kilometers driven per week

Table 2. Multinomial logistic regression model results

Parameter	20% Reduction in Crash Involvement probability				50% Reduction in Crash Involvement probability			
	Coefficient	z-value	Sig.	Odds Ratio	Coefficient	z-value	Sig.	Odds Ratio
Constant	4.971	8.961	***	–	4.917	8.961	***	–
Time	-0.038	-5.426	***	0.963	-0.034	-6.354	***	0.966
Cost	-0.088	-10.662	***	0.916	-0.061	-10.011	***	0.940
Age1 (ref. cat.)	–	–	–	–	–	–	–	–
Age2	-1.010	-3.835	***	0.364	-0.862	-3.214	**	0.422
Age3	-0.860	-2.964	**	0.423	-0.480	-1.628		0.619
Age4	0.037	0.111		1.038	0.128	0.372		1.136
Age5	1.928	1.816	.	6.872	2.186	2.060	*	8.896
Gen1 (ref. cat.)	–	–	–	–	–	–	–	–
Gen2	0.359	2.188	*	1.431	0.338	1.991	*	1.401
P1 (ref. cat.)	–	–	–	–	–	–	–	–
P2	-0.837	-3.319	***	0.433	-1.323	-5.038	***	0.266
P3	-1.011	-3.989	***	0.364	-1.179	-4.463	***	0.308
P4	-0.680	-2.263	*	0.507	-0.781	-2.570	*	0.458
P5	-0.298	-4.896	***	0.742	-2.055	-6.658	***	0.128
V1 (ref. cat.)	–	–	–	–	–	–	–	–
V2	0.189	0.766		1.201	0.501	1.793	.	1.650
V3	0.965	2.842	**	2.624	1.753	4.712	***	5.771
Purp1 (ref. cat.)	–	–	–	–	–	–	–	–
Purp2	0.313	0.998		1.367	0.772	2.440	*	2.165
Purp3	0.306	0.996		1.426	0.566	1.800	.	1.762
Purp4	-0.108	-0.291		0.897	1.302	3.645	***	3.676
Purp5	-1.468	-5.163	***	0.230	-2.163	-6.437	***	0.115
CID1	-0.116	-0.602		0.890	-0.707	-3.484	***	0.493
CID2	0.673	1.910	.	1,960	1.050	2.974	**	2.857
WFC1 (ref. cat.)	–	–	–	–	–	–	–	–
WFC2	0.344	1.882	.	1.411	0.894	4.705	***	2.456
WFC3	1.037	4.196	***	2.822	2.228	8.951	***	9.284
HD1 (ref. cat.)	–	–	–	–	–	–	–	–
HD2	-0.467	-1.241		0.627	-0.766	-2.028	*	0.465
HD3	-0.856	-2.322	*	0.425	-0.868	-2.329	*	0.420
HD4	-1.132	-2.872	**	0.322	-1.429	-3.575	***	0.239
E1 (ref. cat.)	–	–	–	–	–	–	–	–
E2	0.325	1.656	.	1.384	0.875	3.818	***	2.400
E3	0.398	1.796	.	1.489	2.011	8.263	***	7.472
E4	0.952	3.402	***	2.592	2.783	9.449	***	16.161

Significance codes: '***': 0.000 | '**': 0.001 | '*': 0.01 | '.': 0.05 | ' ': ≥ 0.1

- Drivers are willing to offer **higher investments** the more times they were involved in injury crashes
- Drivers traveling the largest distances are **more reluctant** to invest in road safety improvements
- As road safety interventions increase the **time and cost of trips**, the fraction of drivers supporting the interventions decreases
- As **age** increases, drivers' intention to invest in road safety increases, especially drivers ≥65 years old
- Females appear to be **more tolerant** to invest in transport interventions that enhance road safety levels than males
- When the purpose of transportation is **"Going to work"**, drivers are less likely to invest in road safety
- When the purpose of transportation is **"Shopping and Entertainment"**, drivers are more likely to invest in road safety

Crash Cost Calculation

The **individual human cost**, also known of Value of Statistical Life (VOSL), can be derived from a division:

$$HC = Avg_{inc} * WTP * TF/fatalities \qquad (3)$$

- Avg_{inc}: Average household income (Eurostat, 2018) = **8.682€**
- WTP: Willingness to pay = **6.76%**
- TF: Total families (Hellenic Statistical Authority, 2018) = **4.134.540**
- Fatalities: Average deaths annually in road crashes from the most recent period of 2000 – 2016 (Hellenic Statistical Authority, 2018) = **1.378**
- HC: Human cost per road crash fatality for Greece in 2016 = **1.761.154€**

Conclusions

- The vast majority of Greek drivers choose to **reduce the probability** of getting involved in a road crash (slightly or considerably)
- Certain **income categories** are more willing to adapt to new measures which will deliver positive results in addressing road safety issues than others
- Other **characteristics** that influence people's driving behaviour and their preferences towards road safety are driver age, driver gender, purpose of transport
- By quantifying the human cost of crashes, their **economic impacts** can be better understood