

Road Safety on Four Continents

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COST-BENEFIT ASSESSMENT OF SELECTED ROAD SAFETY MEASURES IN GREECE

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Research Objectives

Investigate the basic elements of cost-benefit evaluation techniques through the assessment of selected road safety measures in Greece

- **Use these techniques for the assessment of selected road safety measures in Greece.**
- **Develop an appropriate framework to estimate safety effects and road accident cost in Greece.**
- **Reveal the most important barriers of the assessment techniques.**
- **Identify the efficiency of selected road safety measures.**

Importance of the research

- **Limited budget** for road safety policies and activities.
- **Rational and efficient** approach required.
- Facilitate **decision making** and identification of **policies** with highest return in monetary terms.

Methodological framework

- Estimation of the **safety effect** of road safety measures
 - Identification of the safety effects values through “Before-and-after” studies
 - Weighting defined safety effects by means of Odds-ratio
 - Test X^2
- Estimation of **road accidents cost** in Greece
 - Costs of various components of accidents cost (material damage costs, generalized costs, human costs)
 - Investigation on human cost calculation in Greece
- Implementation of **Cost-Benefit analysis** on road safety measures in Greece:
 - Development of motorways
 - Traffic calming measures
 - Intensification of speed and alcohol enforcement

Safety effect (1)

- The expected **reduction in target accidents/casualties** following the implementation of a treatment, given in the form of a percentage.
- Estimation of the safety effect:

- **Odds-Ratio method**

$$\text{Estimated effect} = [X_a/X_m]/[C_a/C_b]$$

where:

X_a - the number of road accidents observed at the examined area in the "after" period

X_m - the number of road accidents observed at the examined area in the "before" period

C_a - the number of road accidents observed at the control group area in the "after" period

C_b - the number of road accidents observed at the control group area in the "before" period

Safety effect (2)

● Test X^2

- Comparison of the number of accidents occurring in the **area examined** with the accidents occurring in the **control group area**.

$$X^2 = (\Psi - X \cdot A)^2 / (X + \Psi) \cdot A \quad (1)$$

$$\text{where: } A = \Psi_E / X_E \quad (2)$$

- Comparison of X^2 with the X^2_{α} value for a given **probability standard α** and for **$n=1$ freedom standard**.

Road accidents cost in Greece (1)

Estimation of the costs of various components of **accidents cost** for fatal accidents, injury accidents and material damage accidents, including:

- Material damage costs
- Police costs
- Fire brigade costs
- Insurance companies cost
- Court costs
- Lost production output
- Pain and grief
- Rehabilitation costs
- Hospital treatment and rehabilitation
- First aid and transportation costs

Road accidents cost in Greece (2)

- Estimation of **human cost** in Greece based on willingness-to-pay method:

$$\text{VoSL} = (\text{NAEIS}) / (\text{LSE})$$

where:

VoSL: Value of Statistical Life

NAEIS: National Annual family Expenditure on Improving Safety

LSE: expected Lives Saved from this Expenditure annually

Cost of Accident (1999) with:	Killed	Seriously Injured	Slightly Injured
Material Damage cost (€)	28.769	18.175	13.904
Generalised cost (€)	442.467	23.907	6.960
Human cost (€)	612.141	467.703	206.340
Total accident cost (€)	1.083.377	509.785	227.204

1. Cost-Benefit analysis on the development of motorways (1)

- Upgrade two sections of 70 km each, of the main national road axis Patras - Athens - Thessaloniki - Evzoni (~750 km) into **motorway**.
 - **Before:** two-way, one lane per direction, no median
 - **After:** two-way, three lanes per direction, median

Basic road safety related figures in the examined axis
before-and-after the upgrade into motorway

	Before (1986-1990)		After (1996-1999)		Change
	total	per year	total	per year	
Accidents	1279	259	559	140	-46%
Persons killed	369	74	145	36	-51%
Veh-Km (billion)	8,5	2	9,54	2	40%
Accidents per billion veh-Km		153		59	-62%
Killed per billion veh-km		43		15	
Killed per 100 accidents		28		26	-9%

1. Cost-Benefit analysis on the development of motorways (2)

- “Before-and-after” assessment methodology with **large control group**.
- Safety effect was quantified by using the **odds-ratios** technique.

Safety effect of the construction of motorways

	Athens - Lamia sections				Athens - Korinthos sections			
	Treatment group		Control group		Treatment		Control group	
	Before	After	Before	After	Before	After	Before	After
Number of accidents	159	66	437	341	210	79	437	341
Odds	0,415		0,780		0,376		0,780	
Odds ratio	0,532				0,482			
Ln(OR)	-0,631				-0,730			
Safety effect	47%				52%			
Lower limit	27%				64%			
Upper limit	61%				35%			
Number of accidents prevented	157				245			

1. Cost-Benefit analysis on the development of motorways (3)

- **Accidents costs:** calculated by weighting the reference values to the respective proportion of casualties per severity in the examined sections.
- **Total implementation costs:** obtained from the Ministry of Environment, Physical Planning and Public Works. Costs corresponding to the examined "after" period (1996-1999) calculated as a proportion of the total cost of the project and 15% of the total construction cost was considered as maintenance costs.

Cost-benefit analysis on motorways (in terms of safety only)

	Athens - Lamia	Athens - Korinthos
Number of accidents prevented	157	245
Average accident cost	347.920	373.902
Present value of benefits (€)	54.571.805	91.477.809
Total Cost (€)	31.602.789	43.084.780
Benefit - Cost Ratio	1,7 : 1	2,1 : 1

2. Cost-Benefit analysis on traffic calming measures (1)

- Installation of **speed humps** and **woonerfs** in one-lane, one-direction streets between the years 1991 and 1999 in the Municipal Area of Neo Psychiko.
- Implementation cost for **speed humps**: designing and construction/installation costs, road markings. 49 speed humps were installed in 21 one-lane, one-direction roads.
- Implementation cost for **woonerfs**: design cost, configuration and pavement cost, hydraulic works cost, electrical works and sewage pipelines installation. Total area of 100.000m² in 40 local roads was transformed into woonerfs.

2. Cost-Benefit analysis on traffic calming measures (2)

Traffic calming measures implementation cost (1998)

Traffic calming measures	Amount	Cost
Speed humps	49 units	111.518€
Woonerfs	100.000m ²	3.081.438€
Total Implementation Cost	3.192.956€	
Implementation Cost (Period examined)	1.596.478€	

2. Cost-Benefit analysis on traffic calming measures (3)

All injury accidents in one direction - one lane streets

Time period	Area	
	Area examined	Control group
Before (1985-1990)	$X = 36$	$X_E = 101$
After (1994-1999)	$\Psi = 33$	$\Psi_E = 149$
Change	-8.3%	47.5%

- Estimated $X^2 = 3.972 > 3.84$ (X^2 value for 95% probability standard). Statistical significant reduction in accidents.

Safety effect of speed humps and woonerfs

Treatment type	Estimated effect-WME	WME confidence interval
Speed humps and woonerfs in the Municipality of Neo Psychiko	0.621	(0.363, 1.061)

- Safety effect: **38% reduction** in total number of road accidents (**14 accidents prevented**).

2. Cost-Benefit analysis on traffic calming measures (4)

- **Time lost** due to reduced travel speeds:

$$T = D * Q * V * P$$

where:

T: value of time lost due to delays resulting traffic calming measures implementation

D: average delay per vehicle (60 sec)

Q: average daily traffic volume in area considered (8.680 veh.)

V: average value of time (hourly) per vehicle (4,5€/hour)

P: period (260 days/year)

- **Accident cost** for accidents in urban areas: costs of fatal and injury accidents weighted in relation to average distribution of accident casualties per casualty severity in urban areas.

2. Cost-Benefit analysis on traffic calming measures (5)

Calculation of the cost-benefit ratio

	Scenario 1 Safety benefits only	Scenario 2 Including time lost
Present value of benefits		
Number of accidents prevented	14	14
Average accident cost - 1999 (€)	284.667	284.667
Value of time lost - 1999 (€)	-	902.720
Total (€)	3.985.338	3.082.613
Present value of costs		
Implementation cost - 1999 (€)	1.660.337	1.660.337
Cost-benefit Ratio	2,4 : 1	1,9 : 1

- In both scenarios, the implementation of speed humps and woonerfs in a broad local area can be **cost-effective**, despite the high implementation cost.

3. Cost-Benefit analysis on speed and alcohol enforcement (1)

- Since 1998, intensification of road safety enforcement; gradual increase of road controls for the two most important infringements: **speeding, drinking and driving.**

Basic trends of road safety related figures in Greece (1998 - 2002)

	1998	1999	2000	2001	2002	5-year change
injury road accidents	24.819	24.231	23.127	19.710	16.852	-32%
persons killed	2.182	2.116	2.088	1.895	1.654	-24%
vehicles (x1000)	4.323	4.690	5.061	5.390	5.741	33%
speed infringements	92.122	97.947	175.075	316.451	418.421	354%
drink & drive infringements	13.996	17.665	30.507	49.464	48.947	250%
drink & drive controls	202.161	246.611	365.388	710.998	1.034.502	412%

3. Cost-Benefit analysis on speed and alcohol enforcement (2)

- **Enforcement costs:** police labour costs, police vehicle costs and police speed and alcohol enforcement equipment costs (speed cameras, alcoholmeters etc).

Enforcement Implementation Costs 1998 - 2002 (prices of 2002)

	Speed		Alcohol	
	Shifts	Arrests	Shifts	Arrests
Number of infringements	1.007.894		146.583	
Number of activities	62.993	30.237	128.260	14.658
Person-hours per activity	24	14	24	14
Hourly rate (€)	7,50		7,50	
Labour Costs	11.338.808	3.174.866	23.086.823	1.539.122
Total Labour Costs (€)	14.513.674		24.625.944	
Number of vehicles per activity	1	1	1	1
Average distance travelled per activity (Km)	20	5	5	5
Unit Cost per Km (€)	0,10	0,10	0,10	0,10
Vehicle Costs	125.987	15.118	64.130	15.118
Total Vehicle Costs (€)	141.105		79.248	
Total Equipment Costs (€)	159.950	-	4.670	-
Total Implementation Costs (€)	39.524.591			

3. Cost-Benefit analysis on speed and alcohol enforcement (3)

- **Cluster analysis** aiming at identifying groups with similar characteristics within 52 departments of Greece.
- Development of **Poisson regression models** for quantification of the separate effect of various types of enforcement.
- Two categories of models:
 - Models with **no time-halo** in the effect of enforcement
 - Models with a **time-halo** in the effect of enforcement

Safety effect of enforcement 1998 - 2002

Department Group	No time-halo-effect				Two months time-halo-effect			
	I	II	III	IV	I	II	III	IV
Marginal effect* of speed infringements		-1,239		-1,542		-2,224		-2,053
Marginal effects* of alcohol controls		-1,929		-1,373		-2,265		-2,684
Number of accidents prevented		475		297		614		528
Total number of accidents prevented	772				1.142			

*expected accidents prevented from a 1000 infringements/controls increase

3. Cost-Benefit analysis on speed and alcohol enforcement (4)

Cost-Benefit Analysis on speed and alcohol enforcement

	Conservative scenario No time-halo-effect	Best Scenario Two months time-halo-effect
Number of accidents prevented	772	1.142
Average accident cost	309.723	309.723
Present value of benefits (€)	259.313.657	383.471.514
Cost of speed enforcement	14.814.729	
Cost of alcohol enforcement	24.709.862	
Total Implementation Cost (€)	39.524.591	
Benefit - Cost Ratio	6,6 : 1	9,7 : 1

- Nationwide intensification of speed and alcohol enforcement in Greece was found to be **highly cost-effective**.
- Important accident and casualty prevention could motivate **decision makers** towards further improvement of the implementation and monitoring of the measures.

Conclusions (1)

- Cost benefit analyses can provide reliable and interesting results as far as **input data and methodology application** are appropriate.
- **Important benefits** can be obtained with relatively limited resources.
- **Behaviour enforcement** is highly effective (6,6 - 9,7) due to moderate implementation cost and significant casualty reduction.
- **Infrastructure improvement** is less effective (motorways: 1,7 - 2,1, low cost measures 1,9 - 2,4) due to high implementation cost and moderate casualty reduction.

Conclusions (2)

- Several common **technical issues**, which might occur during the Cost-Benefit Analysis evaluations are:
 - correct application of the odds-ratio technique
 - ways for checking the statistical significance of the evaluation results
 - selection of side-effects to be considered along with safety effects
 - correct distinction between the implementation costs and negative side-effects of the measure
- Major **barriers** for performing efficiency assessment of road safety measures are:
 - lack of information on safety effects and costs
 - doubts on the validity of the available values
 - lack of obligatory procedure for the performance of cost-benefit evaluations of safety effects

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