Economic Assessment of Road Infrastructure Safety Schemes in Greece Using Crash Prediction Methodology

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Introduction

The economic assessment of road safety projects is a **valuable tool** that allows decision makers to increase the efficiency of their policies, maximize the contribution of transport to the economy in general and achieve a safer and more balanced relationship between transport stakeholders, road users, society and the environment. Taking into account that funds for road safety are limited, decision makers and road safety stakeholders need to **prioritize activities** and base their decisions on **evidence** and **data**, using appropriate criteria. Especially for road safety, the economic efficiency of measures is a widely used criterion to identify good policies.

Objectives

The aim of this study is to present a methodology for the economic assessment of road infrastructure safety projects using international crash prediction models, adjusted for local conditions and accounting for limited data availability. The development and implementation of the methodology was commissioned and funded by the European Investment Bank (EIB) and carried out in order to assist Egnatia Odos SA (a state owned company) in the assessment of the economic viability of the **Greek Road Rehabilitation and Safety Project**, focusing on the treatment of hazardous locations in the rural road network of Greece.

The examined project

The project was designed during 2012-2015 and was based on an extensive technical and visual review of the national and regional road network to identify sections with increased crash risk. A total length of 15,000km of roads was examined, including 4,200km of national roads and 10,800km of regional roads, spreading over all 13 regions of Greece. The roads examined were mostly rural two-lane two-way roads and did not include motorways and roads inside urban areas. The project resulted in the identification of approximately **7,000 hazardous locations** (HL) spread over **2,500 km** of the aforementioned road network, on 80 different roads.

For each identified hazardous location, low cost road safety interventions, capable of being implemented quickly without the need for further designs, were proposed, selected from a pre-developed list of countermeasures.

Methodology

The economic assessment methodological approach comprises two pillars: **Pillar 1 - Technical Assessment** focuses on the analysis of the proposed road safety schemes and the estimation of the resulting reduction in terms of accident numbers, fatalities and injuries, while **Pillar 2 - Economic Appraisal** focuses on the estimation of costs and benefits in monetary terms, leading to the calculation of the project's Economic Rate of Return (ERR). The technical assessment pillar combines two engineering approaches in road safety, namely reactive and proactive engineering in a holistic method to reliably estimate the benefits of road safety schemes.

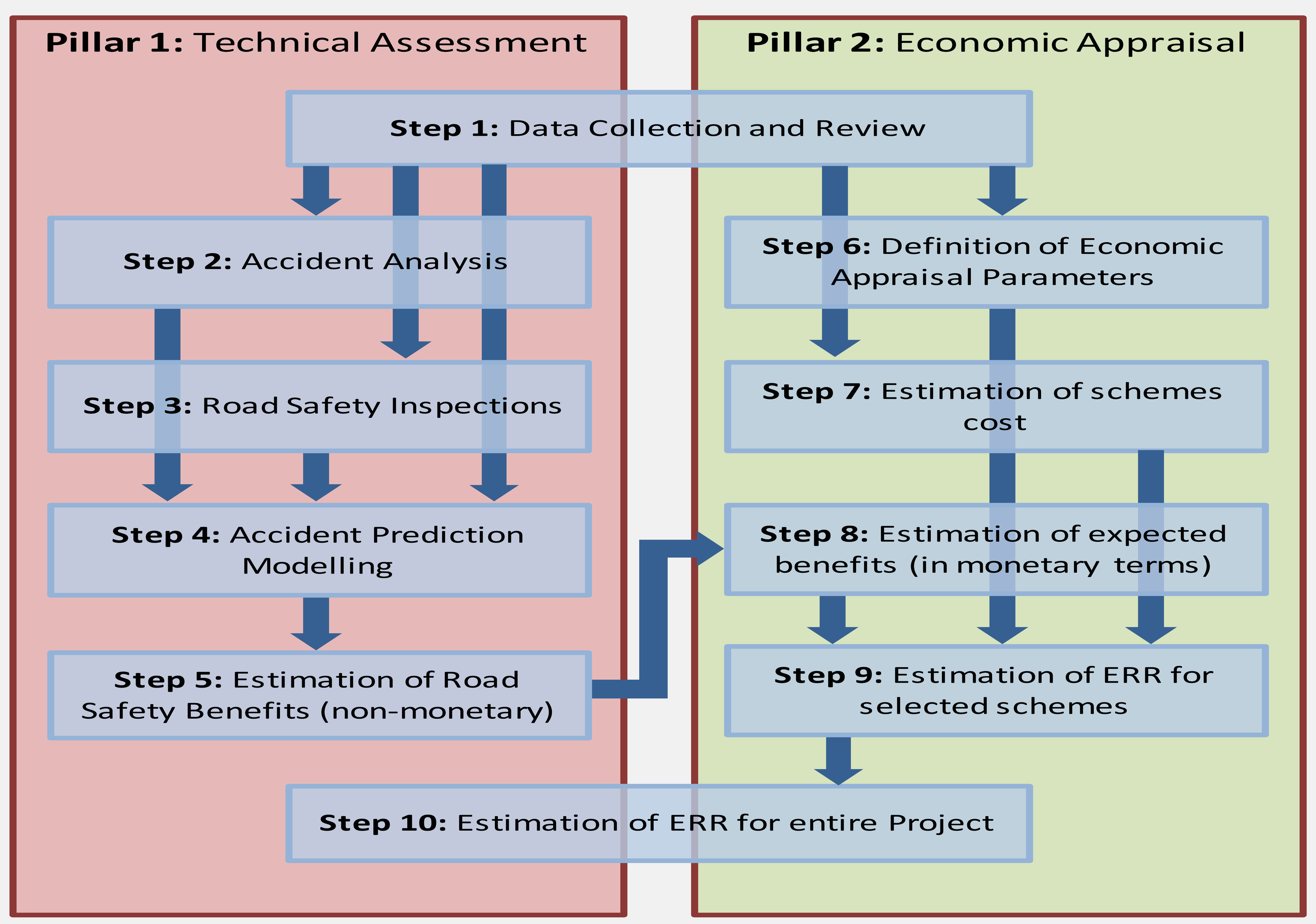

Figure 1. Methodological approach

Data Description

The following types of data were used in the study, retrieved from the sources mentioned in parentheses:

- **Road infrastructure data**, regarding both road geometry and road equipment, on the existing situation as well as the designed countermeasures (respective intervention design studies, verified by means of site inspections)
- **Crash data** (National Road Accident Database by the Hellenic Statistical Authority – ELSTAT)
- **Traffic volumes** (AADTs from local counts and from the National Traffic Model for Greece, suitably adjusted)
- Construction **cost estimations** (bidding documents of the respective designs)

Analysis Scenarios

Two scenarios were assumed:

- **Scenario 1** includes only accidents for which the recorded road and station match those of the respective hazardous location
- **Scenario 2** includes, in addition to the accidents of scenario 1, a percentage of accidents with known road but unknown station: for each road, the ratio of the length of hazardous locations per total road length was calculated. Then, the number of road accidents which occurred in this road but at unknown station was multiplied by the ratio of lengths and the resulting road accidents were assigned to hazardous locations in proportion to their length.

Case Study

The developed methodology was implemented for the economic assessment of the project in the sub-regions of **Imathia**, in northern Greece, and **Viotia**, in central Greece. A total of 116 hazardous locations covering 38.6km of road network were proposed for improvement in Imathia (Figure 2) and 111 hazardous locations covering 42.9km of road network in Viotia (Figure 3). Respective countermeasures, as proposed by the designs, included the installation of 20.1km of safety barriers, construction of 560,000m^2 of anti-skid asphalt wearing course and 1,570m^2 of road markings in these two sub-regions.

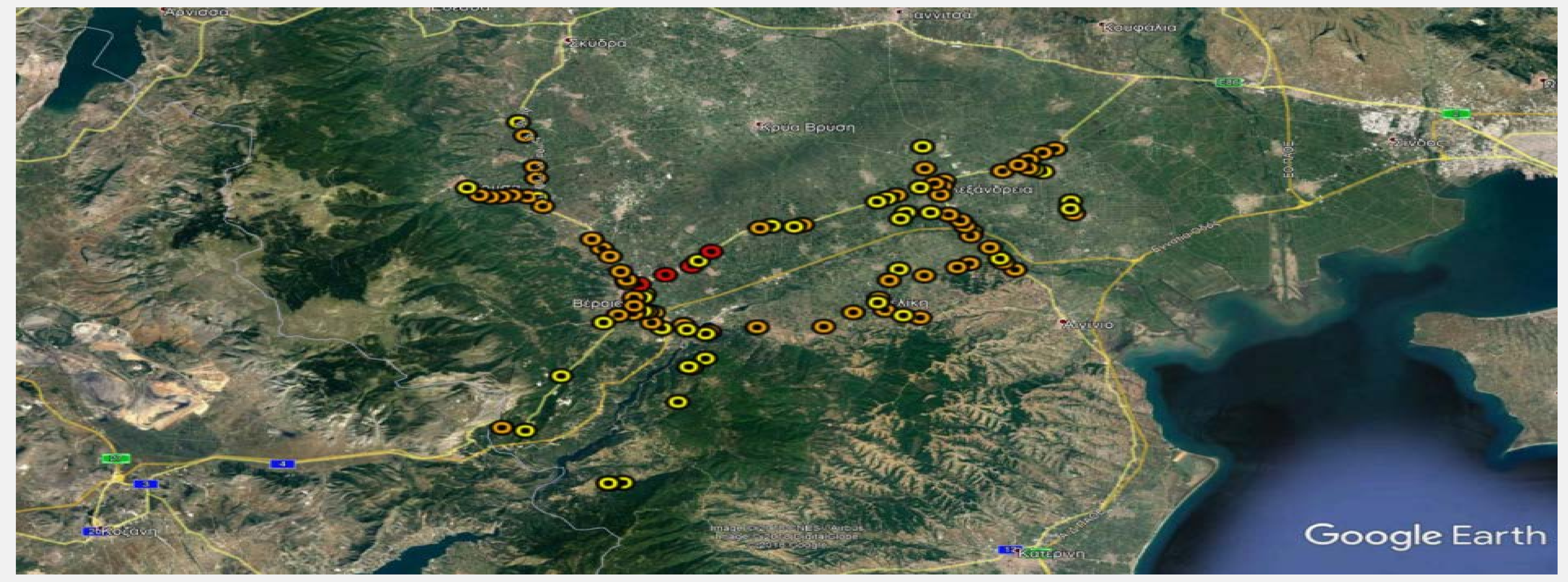

Figure 2. Hazardous locations in the sub region of Imathia.

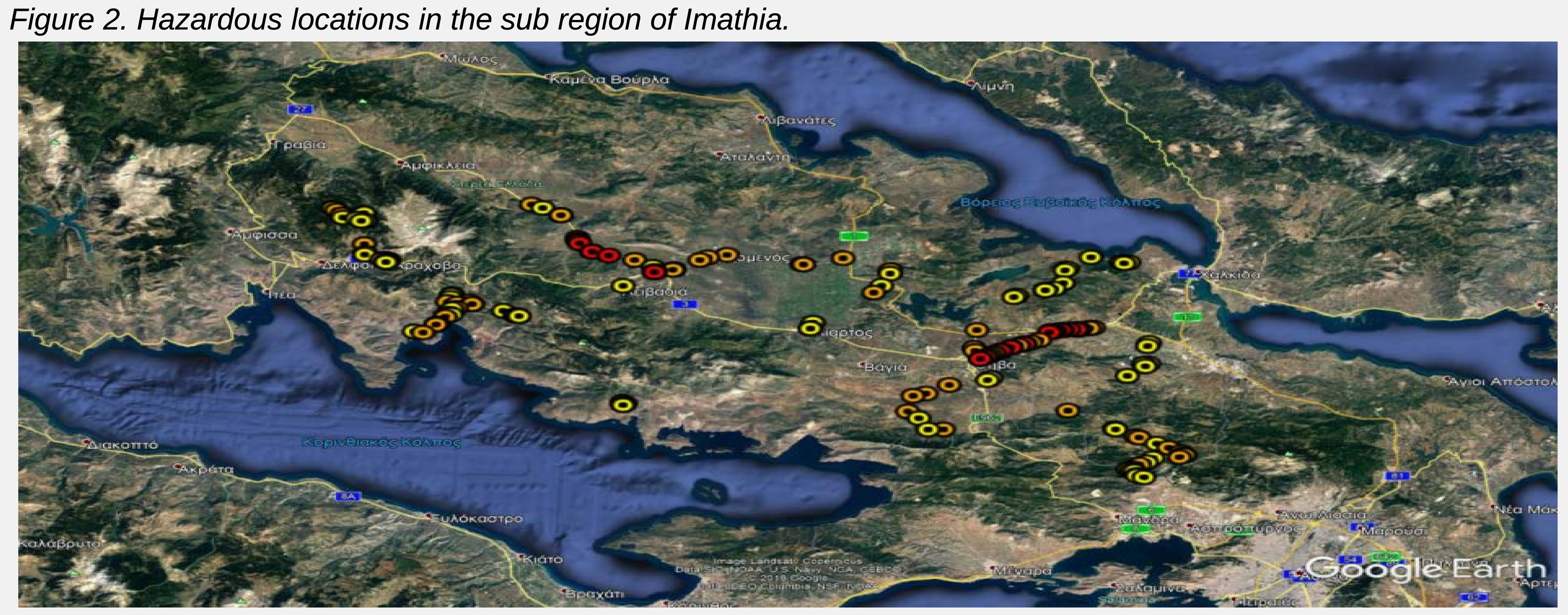

Figure 3. Hazardous locations in the sub region of Viotia.

Segmentation of examined sites and data coding

The roadway was divided into individual sites that were either homogenous roadway segments or intersections. Since the analysis was restricted to the sites examined by the project designers, an initial segmentation was already available. The elaboration of the identified hazardous locations and suggested interventions revealed the following issues: In both sub-regions, certain hazardous locations required splitting. For example, there were sites that included two intersections; these were appropriately split. In other cases, a site referred to a road segment with several horizontal curves, and had to be split to smaller segments, one for each curve. Other hazardous locations were split, in order to have uniform characteristics or to eliminate intermediate sections in which no treatments had been suggested.

An extensive data coding worksheet was developed, into which all data required for accident modeling were inserted for each hazardous location. The coding of infrastructure characteristics (before and after the project) for each site was based on the detailed design drawings and documents of the designs, verified during the site inspections and also using Google Earth maps and Street View.

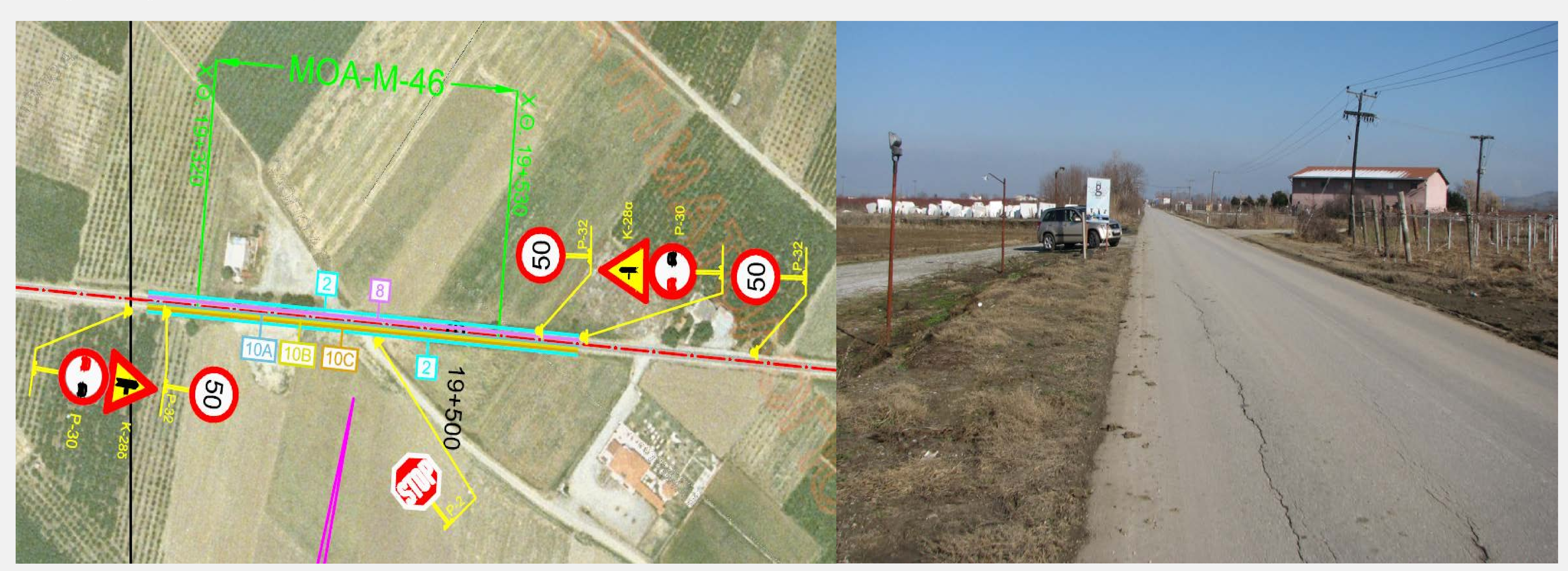

Figure 4. Sites survey data.

The issue of underreporting

The problem of road crash injury under-reporting is typically identified when comparing Hospital and Road Traffic Police data on road crash injuries. Only a limited proportion of non-fatal hospitalized injuries are recorded by the Police, while even less is known about the reporting of less severe (e.g. non-hospitalized) injuries. ELSTAT crash and injuries data, used in the study, originate from traffic police data, and are therefore susceptible to bias from underreporting.

In order to address this potential bias, the following average under-reporting correction coefficients were used, as estimated by relevant research in Greece:

- for fatalities 1.15
- for serious injuries 1.74
- for slight injuries 1.54

Based on the above, the cost-benefit analysis was performed using both approaches: (a) not considering under-reporting, and (b) taking under-reporting into account according to the aforementioned coefficients.

Estimation of Road Safety Benefits

For the estimation of the benefits of the suggested road safety schemes, the predicted number of crashes for Viotia and Imathia assuming project implementation was compared to the predicted number of crashes if the project is not implemented ("Business-As-Usual") and crash reductions per year were estimated.

In order to estimate the number of fatalities, serious and slight injuries saved by implementation of the schemes, the following severity indices were used, based on 2008-2017 data for the rural road network of Greece (not including motorways):

- number of fatalities per 100 crashes: 22.01
- number of seriously injured per 100 crashes: 20.76
- number of slightly injured per 100 crashes: 122.14

Table 1. Estimated road safety benefits from project implementation (Period 2017-2032). Numbers in parentheses do not include adjustment for underreporting.

	Viotia sub-region		Imathia sub-region	
Reduction in:	**Scenario 1**	**Scenario 2**	**Scenario 1**	**Scenario 2**
Fatalities	12 (10)	13 (11)	10 (9)	11 (9)
Seriously injured	17 (10)	18 (10)	14 (8)	15 (9)
Slightly injured	89 (58)	95 (62)	74 (48)	79 (51)

Results of Economic Appraisal

Key parameters for the economic appraisal were assumed as follows:

- analysis timeframe: 15 years
- reference interest rate: 5%
- average service life of countermeasures: 15 years
- countermeasures construction costs: retrieved from relevant design documents
- countermeasures maintenance costs:
  - for the first five years: 0.5% of the construction costs
  - for the next five years: 2.5% of the construction costs
  - for the last five years: 4.5% of the construction costs
- Value of road fatality, serious injury and slight injury (according to relevant study in Greece):
  - Death 2,148,034.20€
  - Serious injury 273,574.25€
  - Slight injury 51,372.70€

The economic rate of return for the project is defined as "**the interest rate at which the project's discounted benefits equal discounted costs**"; a project is considered economically viable if the ERR exceeds a minimum threshold. The results of the ERR estimation for each examined sub-region, along with a preliminary ERR estimation for the whole project in Greece (based on the weighted average reduction of fatalities and casualties in Viotia and Imathia and the actual number of fatalities and casualties in each other sub-region) is presented in Table 2.

Table 2. ERR estimation Results
Numbers in parentheses do not include adjustment for underreporting.

Scenario	Viotia	Imathia	Estimation for the whole Project in Greece
Scenario 1	25.2% (19.5%)	16.6% (11.6%)	16.7% (11.2%)
Scenario 2 (proposed)	27.1% (21.1%)	18.2% (13.1%)	18.2% (12.6%)

Conclusions

On the basis of the above analysis and the experience from the case study in Imathia and Viotia sub-regions, the following aspects are worth noticing.

- A **considerable difference between the ERRs in Viotia and Imathia** is evident in Table 2. In both sub-regions, the estimated reduction of accidents in the examined locations attributed to the road safety schemes was similar: 38.5% in Imathia and 41.0% in Viotia. However, in Viotia approximately 7.3M€ are to be spent for the treatment of 39.3Km of hazardous locations, resulting in 0.19M€ per Km, whereas in Imathia 9.1M€ are to be spent for 27.5Km (for locations outside built-up areas), resulting in 0.33M€ per Km. Also, the examined road network of Viotia has higher traffic volumes and a higher estimated annual increase of AADT according to the data from the National Traffic Model and therefore more road users are expected to benefit from the road safety interventions. All these factors contribute to the increased ERR for the Viotia road safety scheme.
- The **results** of the economic analysis are **not particularly sensitive to changes** in the input data and assumptions. This is evident in Table 2: Scenarios 1 (with underreporting) and 2 (w/o underreporting) and particularly Scenario 1 (w/o underreporting) constitute extreme variations from the suggested scenario, yet the project in all cases is considered economically viable.
- In accordance to relevant international experience, road infrastructure safety investments and especially low cost measures suitable for rapid implementation are characterized by a **very high economic rate of return**, i.e. are very cost-effective.

  This can be attributed to the combination of the **low implementation and maintenance costs** with the **high valuation of their benefit** (e.g. 2.15M€ for every fatality saved). An additional factor is that measures are targeted specifically to locations that exhibit serious safety deficiencies and therefore have a significant impact on crash numbers.