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Evaluation of Road Infrastructure Redesign And ADAS Applications For Traffic Safety

Meng Lu, Rob van der Heijden and Kees Wevers

ABSTRACT

In the end of 1990's, Dutch road infrastructure redesign programmer was launched for improving traffic safety. In the mean time the ongoing development in Advanced Driver Assistance Systems (ADAS) seems to offer viable alternatives. These strategies are not only to a large extent substitutes, but also partly complementary. A notorious problem is the ex-ante evaluation of these strategies. This paper determines strategical traffic safety scenarios, reviews some of the evaluation methods most commonly used in transportation research, and presents Grey Relational Analysis (GRA), a normalization based method, which provides a simple and transparent calculation procedure from which a clear-cut ranking order of strategies derives. The application of GRA to the above mentioned evaluation problem is addressed, and some preliminary results are provided, especially sensitivity analysis is discussed.

Keywords:Evaluation, Traffic safety, Advanced Driver Assistance Systems (ADAS), Duurzaam Veilige Infrastructuur (DVI), Grey Relational Analysis (GRA)

1. Background

The road safety records of the Netherlands is one of the best among the countries in the world However, road traffic accidents are perceived as a major societal problem (see Table 1). They constitute a substantial cost for society in terms of medical costs, payments for sickness benefits, loss of labour capacity, material damage, and increased traffic congestion. In the end of 1990's the Dutch road infrastructure redesign programme, so-called Duurzaam Veilige Infrastructuur (DVI - "inherently safe infrastructure" in English) was launched to improve traffic safety[1], which aims to meet the ambitious Dutch policy targets for 2010: 30% reductions of fatalities and 25% of hospitalization with respect to the 1998 figures. Meanwhile, the development of Advanced Driver Assistance Systems (ADAS) is booming. The expected added value of these systems is enhanced driver comfort, improved road safety and increased road network throughput, of which the second item seems to offer an adequate alternative strategy. Both strategies are to a large extent substitutes, but also partly complementary.

Table 1 Road transportation systems characteristics, The Netherlands 2000[2]

road traffic fatalities 1,082	motor vehicle 127.71×10^9 km	$8{,}469 \times 10^6$ motor vehicles
population $15{,}864 \times 10^6$	bicycle 15.1×10^9 km	$6{,}987 \times 10^6$ passenger cars
area (10^3 km^2) 41,526	motorcyclist 1.7×10^9 km	180×10^3 lorries (3,5 tonnes)
road length (10^3 km) 118.7	mopedist 1.0×10^9 km	accidents cost EUR 8.2×10^9

Implementation of DVI and of ADAS follows completely different scenarios. The DVI implementation is very much decentralised to regional or municipal levels. ADAS, on the other hand, has very much a country-wide or even European dimension. To incorporate more explicit consideration on safety into the decision-making process, a bi-level (macro and micro) decision-making model is required, which is composed by

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various modules. This paper focuses on a Policy Evaluation Module (PEM) and builds a macro quantitative evaluation model for comparing items of quite different nature. The input of the model has been analysed based on in-depth literature study and uses the outcome of other modules, i.e. safety performance, traffic analysis, environmental aspects, and implementation condition. We propose the application of Grey Relational Analysis (GRA) for scenario selection in the area of road traffic safety.

2. Strategies to Improve Traffic Safety

This section addresses DVI, ADAS and combined scenarios, and the analysis of the related safety effects, costs, and relevant social, environmental impacts, and implementation difficulty.

2.1 DVI, ADAS and combined scenarios

The definition of DVI and ADAS scenarios is based on previous research[3]. The two basic DVI scenarios focus on urban roads (i.e. urban distributor and urban access road) and rural roads (i.e. rural distributor and rural access road) respectively. Another DVI scenario includes the whole road network. Five ADAS functions, which can match DVI design requirements, are selected: navigation system with additional functionality (NS), speed assistance (SA), lane keeping assistant (LKA), forward collision avoidance (FCA), and intersection support (IS)[4]. Two basic ADAS scenarios are defined that match as well as possible to the basic two DVI scenarios, based on the most feasible applications from a technology maturity and/or economical feasibility point of view. A full ADAS scenario is taken into account to demonstrate the longer-term full potential of ADAS implementation for traffic safety. The definitions of mixed DVI and ADAS scenarios are based, for the ADAS part, on the-state-of-the-are technology, and assume substitution of those DVI functions whose performance can be easily or better met by ADAS functions. The basic ideas are: (1) even ADAS applications need a good infrastructure design, based on agreed infrastructure design principles; and (2) some DVI functions cannot be matched by ADAS, e.g. roundabouts, separated bicycle routes and vehicle parking separated from the road. Vice versa, not all of the safety related ADAS functions can be matched by DVI, e.g. vision enhancement, driver alertness monitoring, adaptive cruise control (ACC), stop-and-go and autonomous driving, which are not included in this research. The third mixed scenario extends to the whole network, including motorways. The nine scenarios are described below:

Scenario 1 (S1) - DVI, urban - 30 km/h zones, particular bicycle paths or parallel roads, absence of parked vehicles, roundabouts and plateaux.

Scenario 2 (S2) - DVI, rural (extra-urban excluding motorways) - particular bicycle lanes, consistent road markings, plateaux, parallel roads, cancellation of pedestrian crossings, semi-paved shoulders, obstacle free zones, roundabouts, reduction of crossings, shoulder protection, and reconstruction of road sections and junctions.

Scenario 3 (S3) - DVI, complete network - DVI measures for all urban roads, and all extra-urban roads (including rural roads and motorways).

Scenario 4 (S4) - ADAS, urban - NA and SA.

Scenario 5 (S5) - ADAS, rural (extra-urban excluding motorways) - NS, SA and LKA.

Scenario 6 (S6) - ADAS, full - NS, SA, LKA, lane change assistance (LCA), FCA and IS.

Scenario 7 (S7) - mixed DVI and ADAS, urban road - NS, SA and partial DVI on urban roads (e.g. roundabouts, separate bicycle lanes, parking places separated from carriageway).

Scenario 8 (S8) - mixed DVI and ADAS, rural road - NS, SA, LKA and partial DVI on rural roads (e.g. roundabouts, separate bicycle lanes, parking places separated from carriageway).

Scenario 9 (S9) - mixed DVI and ADAS, complete network-combination of scenarios 7 and 8.

2.2 Determination of effects and costs

To investigate the contribution of ADAS/DVI implementation to the improvement of road traffic safety at the national level, a comprehensive evaluation is required. Therefore, safety impacts, as well as other factors related to social, environmental, and economical aspects, and implementation impediments are analysed by quantitative safety assessment methods like regression analysis (e.g. linear, Poisson and negative binomial), historical accident data, before-and-after studies, expert judgement, potential for safety improvement index and simulation models, which will be discussed in a separate paper.

The resulting values (based on national data) for the various attributes for each of the nine scenarios are presented in Table 2.

For further elaboration and comparison of these scenarios for decision support on alternative investment strategies, an adequate evaluation is needed. The following section provides an overview of relevant evaluation methods.

3. Evaluation Methods

An evaluation method provides a recipe for analysis and ranking of different available alternatives for achieving a certain goal or objective. Two major categories of evaluation methods may be distinguished: economics based methods and normalisation based methods.

3.1 Economics based methods

Economics based methods express attribute values as much as possible in a monetary unit as an objective weight measure.

Cost-Benefit Analysis (CBA) is probably the first evaluation method that was developed, and originated as early as 1844 (see Encyclopaedia Britannica 2002). CBA is based on economic welfare theory, and aims at selecting so-called efficient projects (or policies). Efficiency is defined in terms of maximisation of welfare, and is evaluated based on the Pareto criterion, which states that a project that makes at least one individual better off, while keeping others as well off, improves welfare. However, CBA cannot deliver this exactness in practical reality, due to various severe limitations[5,6].

Planning Balance Sheet (PBS) was proposed by Lichfield in 1956[7]. It tries to identify and separate the impacts of different alternatives for different groups (producers and consumers). Costs and benefits are expressed in monetary terms if possible, but may otherwise be entered in any physical measurement unit or score, or even in descriptive terms. A critique of the methods is that it only addresses a very high level goal like "enhancing community welfare" while impacts only have a meaning in relation to a well-defined objective[8].

Goals-Achievement Matrix (GAM) was proposed by Morris Hill[10]. The core idea is to view costs and benefits always in terms of achievement of objectives, which are clearly defined in operational rather than abstract sense. For each goal that can be identified, the applicable unit of measurement is established, in quantitative terms if possible, otherwise in qualitative terms. GAM performs a trade-off of benefits and costs across sectors per objective. It is quite capable to express complexity of decision problems. However, GAM is complex and costly, that it does not give a quick answer.

Other variants are *cost-effectiveness analysis* (CEA), *cost-utility analysis* (CUA), *environmental impact reviews*, *profit-ability assessment and fiscal impact analysis*[6].

3.2 Normalization based methods

Instead of putting efforts in valuing benefits and costs, or defining better methods to do it, normalisation based methods completely abstain from it, and in replacement apply a normalisation to the attribute vectors, by transformation to dimensionless values, which then enables to compare attributes of different character. In addition in most cases a subjective set of weights is applied to the attribute categories. These are the methods generally referred to as multicriteria analysis (MCA) methods. There exist a large number of normalization based methods. This paper discusses some well-known and widely used methods in this category:

Analytical Hierarchy Process (AHP) was developed by T.L. Saaty[9]. In this method per attribute the weight of each alternative is established by pairwise comparison, using a fixed scale of scores ranging from 1 to 9, and the reciprocals. From these scores a weight vector is calculated for each of the attributes, expressing the weight per attribute of the different alternatives. Different approaches are in use for this so-called eigenvector calculation. Multiplication of attribute weight and alternative weight for that particular attribute, and summation of these scores per alternative provides an overall priority score for each of the alternatives, from which a ranking can be derived. This method is the clear hierarchical structuring of the decision problem, and of the criteria, clarifying their relative importance. A disadvantage is the artificial limitation to the 9 points scale.

PROMETHEE (Preference Ranking Organization METHod for Enrichment Evaluations) was developed by J.P. Brans[10,11]. It is an outranking method based on comparison of the pairwise outranking relationships between attributes for each of the attributes. For each of these relationships, two so-called preference indexes are calculated. The basis for this is the value (v) difference for an attribute (k) for the considered pair of alternatives a and b, denoted as $d = v_k(a)–v_k(b)$. This value difference is used as independent variable in a generalised criterion function. Six different types of generalised criterion functions are most frequently used. The PROMETHEE method needs much less inputs, but it does not provide structuring possibility. Additionally the generalised criteria have to be defined, which is not seen as obvious by an inexperienced user.

Other main normalisation based methods are *ELECTRE* (ELimination Et Choix Traduisant la RÉalité, in English “elimination and choice translating the reality”)[12,13], *Simple Additive Weighting* (SAW)[14], *TOPSIS* (Technique for Order Preference by Similarity to Ideal Solution)[15], *fuzzy evaluation*[16,17] and *Grey Relational Analysis* (GRA).

3.3 Discussion of evaluation methods

Each method in both categories has its advantages and limitations. No method is able to provide fully satisfying results, and there is often room for arguments. All methods try to provide a ranking of alternatives, by calculating a resulting number per alternative. The economics based methods express attribute values as much as possible in a monetary unit. This appears to be very difficult in practice, but the less stringent this condition is applied, the more difficult it becomes to obtain a clear analytical answer. The normalization based methods try to remove the issue of incomparable units, but none of them is founded on a fundamental theory. Also they are cursed with the rank reversal problem (ranking of alternatives may sometimes be reversed when an extra alternative is added to the existing set). Each of these methods is in fact no more than an advanced calculation recipe, and not every method is always able to provide an unambiguous order. This paper applies a normalisation based GRA evaluation method. Section 4 introduces the method, and provides some arguments why it deserves some more attention. Section 5 explains the recipe of GRA by applying the method to the problem formulated in section 2.

4. Grey Relational Analysis

4.1 Introduction

Grey system theory was developed in 1982 by Julong Deng in China[18], and aims to describe and analyse abstract systems, which are based on logical reasoning. The term grey stands for poor, incomplete and uncertain, and is especially used in relation to the concept of information. To substantiate the structural characteristics of a system, information concerning the system needs to be processed. Grey system theory tries to deal with situations where such information is incomplete or unreliable. Grey Relational Analysis (GRA) is a derived evaluation model which is based on the concept of grey relational space (GRS), one of the elements of grey system theory mainland China and Taiwan[19~22], but hardly known in western countries, although sometimes attempts are made for wider dissemination[23].

4.2 GRA evaluation method

In GRA, the attributes may be of any relevant category, and the original units may be applied. Like in other normalisation based methods, a matrix of *i* alternatives and *k* attributes is created, and the attribute vectors need to be expressed in dimensionless (hence comparable) units and similar scales. Different approaches for normalisation may be used.

The GRA community has seen quite extensive discussions on normalisation, the so-called data pre-processing, to prove that the original and the resulting attribute vectors have a linear relationship, without any distortion[24~26]. In this paper the normalisation method of Wu & Chen[25] is adopted. The main reason for this is the fact that this normalisation method solves the difficulties of providing a value for the distinguishing factor to determine the grey relational coefficients (see formula (5)).

The method[25] takes into account the type of the attribute (benefit, costs or optimisation), and normalises to a scale [0,1]. For benefit type attributes the formula is:

$$x_i^*(k) = \frac{x_i(k) - \min_k x_i(k)}{\max_k x_i(k) - \min_k x_i(k)} \qquad (1)$$

where $\max_k x_i(k)$ is the maximum value of attribute *k* for alternative *i*, and $\min_k x_i(k)$ is the minimum value of attribute *k* for alternative *i*. For cost type attributes the formula is:

$$x_i^*(k) = \frac{\max_k x_i(k) - x_i(k)}{\max_k x_i(k) - \min_k x_i(k)} \qquad (2)$$

and for optimisation attributes, and attributes with a clearly defined targeted value:

$$x_i^*(k) = 1 - \frac{|x_i(k) - x_{ob}(k)|}{\max\{\max_k x_i(k) - x_{ob}(k),\, x_{ob}(k) - \min_k x_i(k)\}} \qquad (3)$$

where $x_{ob}(k)$ denotes the targeted (objective) value of attribute *k*, which can be determined, e.g. by a certain policy goal.

Then the reference series (or vector of best values) is identified. Which value for a certain attribute defines the value of the reference series depends on the type of the attribute. In general for a benefit type attribute the highest value is taken, for a cost type attribute the lowest value, and for the 'targeted value' category the predetermined preferred or optimal value.

For each alternative vector (in GRA also called a compared series, because each alternative vector is compared with the reference series) the difference of the reference vector and the alternative vector is calculated:

$$\Delta_{0i}(k) = |x_0(k) - x_i(k)|, \quad k = 1, 2, \cdots, n \qquad (4)$$

Such difference for alternative *i* and attribute *k* is called the grey relational coefficient for that attribute at point *k*. The grey relational coefficient for each element of an alternative vector or compared series is defined as:

$$\gamma(x_0(k), x_i(k)) = \frac{\min_{i,k} |x_0(k) - x_i(k)| + \zeta \max_{i,k} |x_0(k) - x_i(k)|}{|x_0(k) - x_i(k)| + \zeta \max_{i,k} |x_0(k) - x_i(k)|} \qquad (5)$$

where $\gamma(x_0(k), x_i(k))$ denotes grey relational coefficient of attribute *k* for alternative *i*, $x_0(k)$ denotes the element of the referential series for attribute *k*, $x_i(k)$ denotes the element of the compared series for attribute *k*, and $\zeta \in (0,1)$ denotes the identification or distinguishing coefficient[24,27]. A larger value of this coefficient increases the differences between the values of the coefficients in each attribute vector, and therefore the differences of the values within the ranking vector. This coefficient and its value has been the subject of extensive discussion. It has been argued that its value can be set equal to 1 if the normalisation of [22] is used.

The grey relational grade for the

compared series x_i in terms of weight w_k is given as

$$\Gamma_{0i} = \sum_{k=1}^{n} w_k \gamma_{0i}(k) \qquad (6)$$

where w_k is the k^{th} weight of $\gamma_{0i} = \gamma(x_0(k), x_i(k))$.

The grey relational grade of a compared series provides a measure of how good this series is compared with the reference series, which is based on the best values for each attribute over all alternatives. In a first approximation (or if they are not relevant) the weights may be put all equal to $w_k = 1/n$, and variation of the weights may be used for sensitivity analysis. The set of grey relational grades for the different alternatives provides the ranking vector for these alternatives.

Weighting is a crucial issue for normalization based methods. A weight is a subjective judgement about the importance of an attribute as compared to other attributes. This paper argues that weighting problem may be performed by adding or removing attributes, by variation of certain input values and weights of the attributes through sensitivity analysis because of considerable uncertainty in the evaluation process. Therefore, to use weights as a last step in the GRA procedure as one of the parameters for such sensitivity analysis is proposed.

In general, GRA includes some of the positive aspects of both economics and normalisation based methods, and besides this has its own unique characteristics for evaluation. In GRA original values can be used, even negative values for attributes are also allowed[26], which may be of use for the referenced application, e.g. side-effects of ADAS/DVI implementations for improving traffic safety. While other normalisation based methods generally have a problem to cope with negative values. The GRA method requires only relative accuracy of attribute values within each attribute vector, and not absolute accuracy, which provides an essential difference of this method with the economics based methods, and some of the normalisation based methods like ELECTRE and TOPSIS. This is an advantage for the problem case of this paper, as attribute values for the ADAS scenarios are difficult to obtain, and will be estimated relative to the DVI scenarios.

However, GRA is not a perfect method. In the current model the groups who gain and pay are mixed, and these may be separated by extending GRA with elements of the evaluation framework provided by the PBS and GAM approaches. As the proposed procedure of GRA is very robust, the method may also be easily extended to cover multi-objective evaluation problems[28,29].

5. Application of GRA

5.1 GRA application process

In this section, the GRA method is applied to the problem that was defined in section 2. The process of evaluating the various ADAS and DVI implementation strategies by the application of GRA is addressed in Fig. 1, and the output form is presented in Table 2.

The result of ranking shows the following priority sequence of the nine scenarios from high to low, denoted in the special GRA notation:

$S6 \succ S5 \succ S9 \succ S5 \succ S4 \succ S7 \succ S8 \succ S3 \succ S2 \succ S1$.

5.2 Sensitivity analysis

A sensitivity analysis has been performed by varying two parameters, attribute weights and attribute values. No addition or removal of attributes has been tested.

A strategy for sensitivity analysis based on weights has been developed. The weight vector cannot be obtained by modelling, but may be obtained from experts views, or e.g. by applying AHP or other normalisation based methods. The preliminary result (see Table 4 and Fig. 2) assumes that the weights (*Wj, j=0,1,2,3*) for each attribute are equal (*W0*). Based on unequal weights, three groups of weighs for attributes (k=1,2,3,…,15) are determined by experts (see Table 3).

Another sensitivity analysis is by varying ADAS costs estimation, and safety effects of ADAS estimation at low (L), medium (M) and high (H) level respectively, denoted as:

C_{ADAS} - costs of full ADAS (S6)

E_{ADAS} - safety effects (accident frequency, fatality and hospitalisation) of ADAS applications compared with DVI implementations (S4, S5, S6)

Table 4 provides a summary of the ranking results of the nine scenarios, ranging from 1 for the most favourable option to 9 for least favourable option, produced by the application of a sensitivity analysis to the results obtained by GRA, i.e. when E_{ADAS} and/or C_{ADAS} are at low (L) and high (H) level respectively, and applying weights *Wj*, *j=0,1,2,3*.

6. Conclusions

In this paper a comparison is made between the effects on traffic safety of infrastructure related measures according to the Dutch DVI programme, and of the implementation of ADAS applications. Nine scenarios are analysed with Grey Relational Analysis (GRA). The GRA evaluation method provides a simple and transparent calculation procedure to compare various alternatives with the theoretical optimal solution within the values provided by the set of all considered alternatives, and to establish a clear-cut ranking order of these alternatives.

The result clearly indicates that for improving traffic safety, the ADAS scenarios (S4, S5, S6) and the combined ADAS/DVI scenarios (S7, S8, S9) are better than the DVI scenarios (S1, S2, S3), taking into account all criteria (costs as well as the social, economic, environmental and implementation effects). In general, ADAS measures perform better than DVI measures to enhance road traffic safety. However, implementation of such scenario is not feasible before 2010, in the first place because of technology feasibility, but also due to policy issues. Therefore, the best recommendation at a national level would be to implement scenario S9 (the combination of ADAS and DVI).

A crucial point to keep in mind is that ADAS applications need a good infrastructure design, based on agreed infrastructure design principles. An evaluation method provides a tool for assisting decision making, but no algorithm can act as a complete substitute for human judgement.

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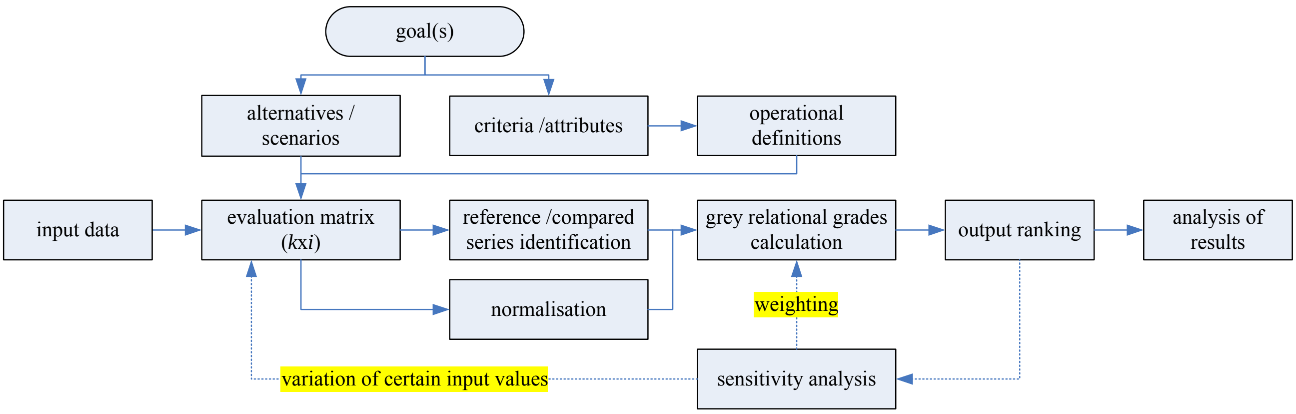

Fig. 1 GRA evaluation process model

Table 2 Outline of output form for GRA results

k	scenarios → attributes ↓	DVI			ADAS			ADAS & DVI		
		S1 urban	S 2 rural	S3 nation	S4 urban	S5 rural	S6 nation	S7 urban	S8 rural	S9 nation
1	accident red %	14.20	5.60	19.81	16.15	6.22	25.26	16.55	6.38	22.93
2	fatality reduc. %	15.88	26.03	45.69	17.47	29.67	57.11	19.06	32.28	51.34
3	hospital. reduc.%	22.55	15.41	40.19	24.81	17.57	50.24	27.06	19.11	46.17
4	comfort & conv.	1	2	2	7	8	9	6	7	7
5	emergency	1	1	1	9	9	10	8	8	8
6	emission reduc.%	0	0	0	10	9	12	9	8	9
7	reduce noise	1	1	1	3	4	5	2	3	3
8	network capacity	2	2	2	1	1	3	2	2	2
9	land use	2	1	1	10	10	10	7	7	7
10	fuel consump. %	0.00	0.00	0.00	16.00	12.00	14.00	16.00	12.00	14.00
11	time saving %	0.00	0.00	0.00	10.00	8.00	9.00	10.00	8.00	9.00
12	pub acceptance	5	6	6	4	5	5	4	5	5
13	tech difficulty	1	1	1	2	2	8	2	2	2
14	policy difficulty	6	6	6	5	5	9	5	5	5
15	costs (mil. EUR)	1632	3215	4847	4500	6056	15056	6056	9183	10739
	Γ_{0i}	0.2500	0.2795	0.3113	0.3531	0.3536	0.4921	0.3464	0.3429	0.3874

Table 3 Attribute weights given by experts

k	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
W1	0.24	0.24	0.24	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.17
W2	0.19	0.19	0.19	0.01	0.01	0.01	0.01	0.17	0.01	0.01	0.01	0.01	0.01	0.01	0.16
W3	0.18	0.18	0.18	0.19	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.17

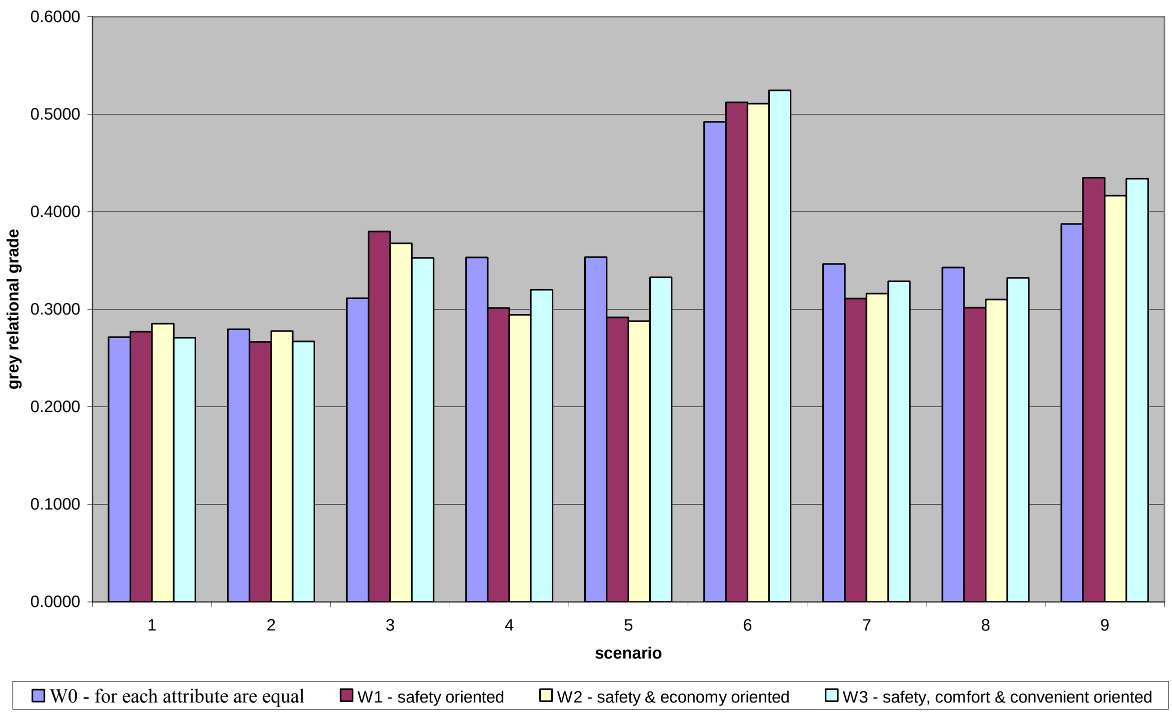

Fig. 2 Sensitivity analysis by weighting

Table 4 GRA evaluation results

C_{ADAS}	weights	E_{ADAS}																										
		L									M									H								
	W0	9	8	7	4	3	1	5	6	2	9	8	7	4	3	1	6	5	2	9	8	7	4	3	1	6	5	2
	W1	8	9	3	6	7	2	4	5	1	8	9	3	6	7	1	5	4	2	8	9	3	7	6	1	5	4	2
	W2	7	9	3	6	8	1	5	4	2	8	9	3	6	7	1	5	4	2	8	9	3	7	6	1	5	4	2
L	W3	8	9	3	7	5	1	6	4	2	8	9	3	7	5	1	6	4	2	9	8	6	7	4	1	5	3	2
	W0	9	8	7	3	4	1	5	6	2	9	8	7	4	3	1	5	6	2	9	8	7	4	3	1	5	6	2
	W1	8	9	3	5	7	1	4	6	2	8	9	3	6	7	1	4	5	2	8	9	3	6	7	1	4	5	2
	W2	7	9	3	6	8	1	4	5	2	8	9	3	6	7	1	4	5	2	8	9	3	6	7	1	4	5	2
M	W3	8	9	3	7	4	1	5	6	2	8	9	3	7	4	1	5	6	2	8	9	5	7	4	1	6	3	2
	W0	9	8	7	3	4	1	5	6	2	9	8	7	3	4	1	5	6	2	9	8	7	4	3	1	5	6	2
	W1	8	9	3	5	7	1	4	6	2	8	9	3	5	7	1	4	6	2	8	9	3	5	7	1	4	6	2
	W2	7	9	3	6	8	1	4	5	2	8	9	3	6	7	1	4	5	2	8	9	3	6	7	1	4	5	2
H	W3	8	9	3	6	4	1	5	7	2	8	9	3	7	4	1	5	6	2	8	9	4	7	3	1	6	5	2
scenario number		1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9
road category		u	r	n	u	r	n	u	r	n	u	r	n	u	r	n	u	r	n	u	r	n	u	r	n	u	r	n
scenario type		DVI			ADAS			comb.			DVI			ADAS			comb.			DVI			ADAS			comb.		

Road category: u - urban roads; r - rural roads; n - national network (including urban roads, rural roads and motorway)
Scenario type : DVI - infrastructure redesign only (scenario 1,2 and 3); ADAS - ADAS applications only (scenario 4,5 and 6); comb. - combination of DVI and ADAS (scenario 7,8 and 9)