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Prioritizing highway safety improvement projects: A multi-criteria model and case study with *SafetyAnalyst*

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Abstract

This paper presents a multi-criteria model for prioritizing highway safety improvement projects, in which a set of criteria related to the project ' s technical, economic, and social impacts are properly weighted in consideration. The proposed model features an Analytical Hierarchy Process (AHP) framework to tackle the multi-criteria decision making problem. Different from the conventional AHP, this paper adds a fuzzy scale level between the criteria level and the alternative level, which offers the advantage of preventing the vagueness and uncertainty on judgments of the decision-maker(s). Such a unique modeling feature is further embedded with a non-linear optimization formulation to maximize the consistency in pair-wise comparison and weight estimation for each criterion. Case study results reveal that the proposed model is efficient not only for selecting the most suitable project for a specific site, but also for determining the priorities for implementing those suitable projects among multiple sites given the budget constraint. Comparative study between the proposed model and the existing ranking methods has also indicated its capability to capture the comprehensive impacts of all contributory factors which have been neglected by most existing single multi-criteria approaches during the safety project selection process. The clarity of model inputs, ease of synthesizing the final score of each candidate project, and the interpretation of results with respect to different selection criteria offer its best potential to be used as an effective tool for highway safety managers to assess and refine the safety improvement investments.

Highlights

► We introduce a multi-criteria model to prioritize highway safety investments. ► An AHP embedded with fuzzy scaling and non-linear optimization is used. ► We evaluate the model with cases from *SafetyAnalyst*. ► The model offers an effective tool for highway authorities in decision making.

Keywords

Highway safety; Multi-criteria approach; Analytical hierarchy process; Fuzzy logic; Nonlinear optimization

Figures and tables from this article:

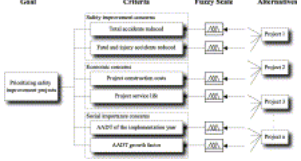

Fig. 1. The proposed hierarchical AHP structure.

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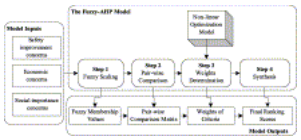

Fig. 2. A graphical illustration of project ranking process with the proposed fuzzy-AHP model.

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Table 1. An example of discrepancies in existing ranking methods.

Note: P *i* = Project *i*; FI = Fatal and injury accidents reduced; TOT = Total accidents reduced; CC = Construction cost; SB = Safety benefit; CE = Cost effectiveness; CE_EPDO = Cost effectiveness equivalent-property-damage-only; BC_ratio = Benefit cost ratio; NB = Net benefit; AHP = The proposed fuzzy-AHP model.

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Table 2. Detailed description for each criterion.

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Table 3. Notation of key parameters used in the proposed model.

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Table 4. Prioritizing safety improvement projects with the proposed AHP model — inputs and results.

Note: # Total accidents reduced = Number of total accidents reduced; # FI accidents reduced = Number of fatal and injury accidents reduced; P *i* = Project *i*.

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Table 5. The most suitable project selection at each site.

Note: P *i* = Project *i*.

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Table 6. Implementation plans for the illustrative case within different budgets.

Note: P *i* = Project *i*.

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Table 7. Spearman ' s correlation coefficients, based on AHP.

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Table 8. Summary of sensitivity analysis of ranking results on AADT.

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