Assessment of road safety performance based on Entropy-RSR model

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Abstract. This paper develops a hybrid decision-making model, Entropy-RSR, for benchmarking road safety for Southeast Asian countries at the regional level. This model generates ranking and grouping of the countries, which provides policymakers and practitioners with a valuable tool for policymaking and decision-making in road safety management.

Keywords: Road safety performance; Policymaking; Decision-making; Southeast Asia; Entropy; RSR.

1. Introduction

In today's globalized world, road traffic accidents pose a serious threat to people and economies worldwide [1]. Each year, millions of lives are lost, and tens of millions of people are getting injured due to traffic accidents. This not only results in a significant loss of human life, but also leads to substantial economic damages. Meanwhile, in the Southeast Asian region, this challenge becomes even more severe, where traffic accidents may account for 3-5% of a country's GDP [2]. Faced with this harsh situation, it is necessary to use active measures to enhance road safety, reduce accident casualties, and stimulate economic growth.

However, conducting systematic road safety reviews in a standardized manner is not an easy task. This process involves a series of challenges, including weight distribution, data aggregation, and grouping [3]. While various methods have existed in the past to provide reference points for assessments, there has yet to be an integrated model that combines these three critical steps. To address this challenge, we have developed the Entropy-RSR evaluation model. This integrated assessment model not only enriches the database of multi-criteria decision-making methods but also offers crucial safety review guidance to Southeast Asian nations, providing a path forward for future policymaking and action plans.

Through this study, we will conduct deep research into the global road safety issue and the unique circumstances in the Southeast Asian region, as well as how our Entropy-RSR model plays a vital role in enhancing road safety, reducing economic losses, and promoting sustainable development. This research offers new approaches to solve this pressing issue, with the potential to make significant contributions to future road safety improvements.

2. Data

2.1 Safety performance indicators (SPIs)

Safety performance indicators (SPIs) are important instruments for policymaking. In this study, based on the literature review, the SPIs are primarily divided into three categories: Safer Product, Safer People, and Safer System, as shown in Figure 1.

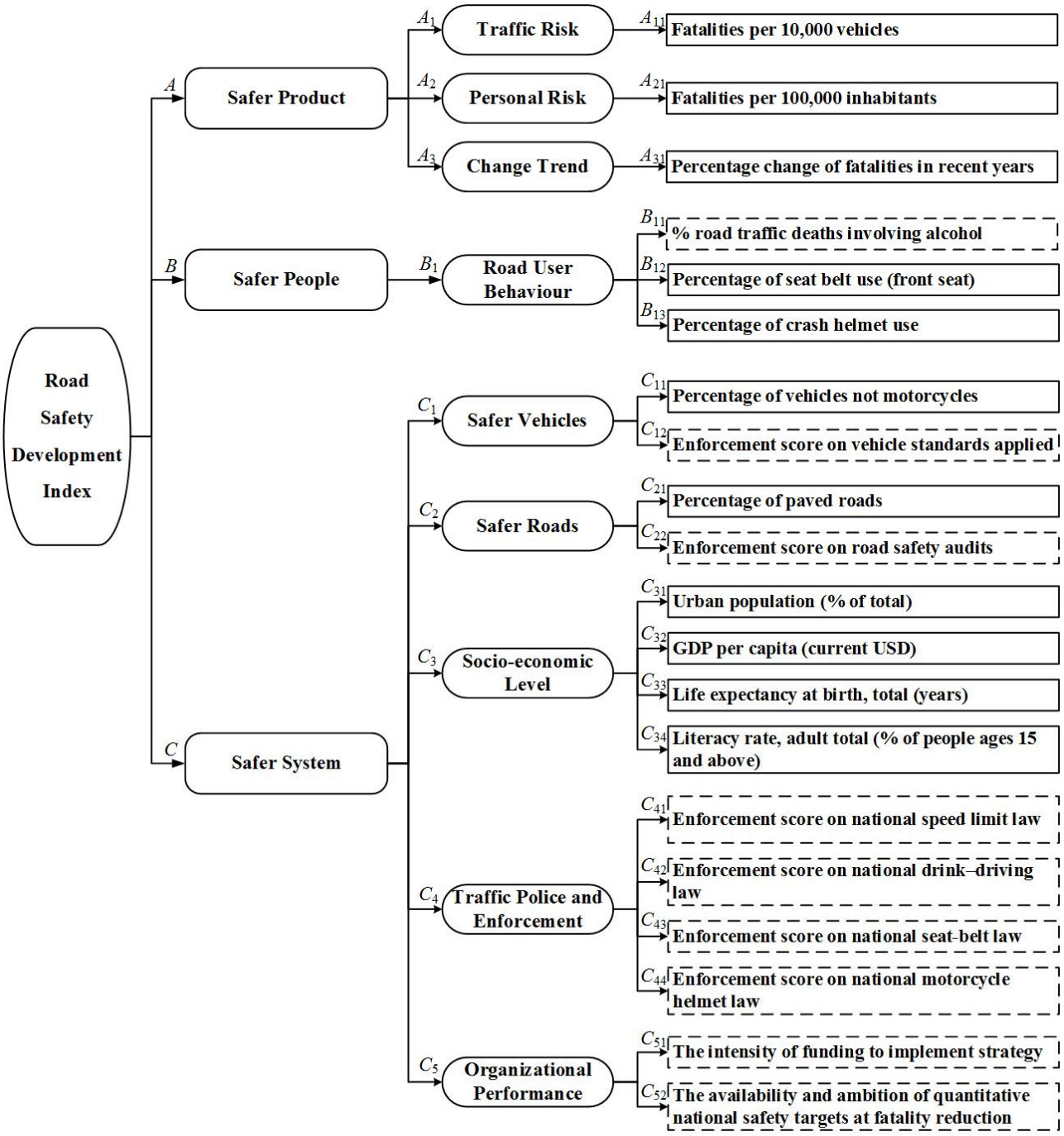

Figure 1 SPIs applied in this study [4].

2.2 Data collection

Data on the safety performance indicators were collected from the World Health Organization [5-8] and World Bank [9] for 11 countries in Southeast Asia for four years (2009, 2013, 2015, and 2018). They are Brunei (BN), Indonesia (ID), Cambodia (KH), Laos (LA), Myanmar (MM), Malaysia (MY). Philippines(PH), Singapore(SG), Thailand(TH), Timor-Leste(TL), Vietnam(VM).

3. Methodology

Step 1: Decision matrix construction

Thus, the MCDM problem that contains m alternatives (countries in this case study), each with n criteria can be concisely expressed in a matrix format as follows:

$$X = \begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_m \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \cdots & C_n \end{array} \\ \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \end{array} \tag{1}$$

Step 2: Rank transformation
Conduct the rank transformation for each of the n indicators.
For benefit criteria

$$R_{ij} = 1 + (m-1)\frac{X_{ij} - X_{j\min}}{X_{j\max} - X_{j\min}} \tag{2}$$

For cost criteria

$$R_{ij} = 1 + (m-1)\frac{X_{j\max} - X_{ij}}{X_{j\max} - X_{j\min}} \tag{3}$$

Finally the rank transformed decision matrix is:

$$R = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix} \tag{4}$$

Step 3: Weight of the criteria determination
Entropy value of the criteria

$$E_j = -\frac{1}{\ln m}\sum_{i=1}^{m} p_{ij} \ln p_{ij} \tag{5}$$

where

$$p_{ij} = \frac{X_{ij}}{\sum_{k=1}^{m} X_{kj}}$$
$$i = 1, 2, \cdots, m; j = 1, 2, \cdots, n \tag{6}$$

The weight of the criteria is calculated as:

$$w_j = \frac{(1 - E_j)}{\sum_{k=1}^{n}(1 - E_k)}; j = 1, 2, \cdots, n \tag{7}$$

Step 4: Composite index value calculation
The RSR value for each alternative is obtained as:

$$RSR_i = \frac{\sum_{j=1}^{n} r_{ij} w_j}{m}, i = 1, 2, \cdots m \tag{8}$$

4. Result

4.1 Ranks

Table 1 presents the RSR scores and corresponding rankings of the countries across the four years.

Table 1 Ranking of countries over the four years.

Country	ISO code	2018		2015		2012		2009	
		Score	Rank	Score	Rank	Score	Rank	Score	Rank

Brunei	BN	0.609	2	0.814	1	0.795	2
Indonesia	ID	0.368	6	0.365	5	0.519	6
Cambodia	KH	0.276	9	0.297	8	0.497	8
Laos	LA	0.237	11	0.289	9	0.484	10
Myanmar	MM	0.292	8	0.262	10	0.512	7
Malaysia	MY	0.669	1	0.716	2	0.587	3
Philippines	PH	0.426	5	0.407	4	0.580	4
Singapore	SG	0.580	3	0.578	3	0.808	1
Thailand	TH	0.473	4	0.328	6	0.549	5
Timor-Leste	TL	0.251	10	0.204	11	0.290	11
Vietnam	VN	0.343	7	0.327	7	0.495	9

From Table 1, Brunei, Malaysia, and Singapore are the three best-performing countries with the highest performance in road safety. While Cambodia, Laos, and Timor-Leste are the three worst-performing countries with the lowest road safety performance.

4.2 Groups

Table 2 presents the grouping results of the 11 countries over the four years.

Table 2 Grouping of countries over the four years.

Country	ISO code	2018	2015	2012	2009
Brunei	BN	1	1	1	2
Indonesia	ID	2	2	2	2
Cambodia	KH	2	2	2	3
Laos	LA	3	2	2	2
Myanmar	MM	2	2	2	2
Malaysia	MY	1	1	2	1
Philippines	PH	2	2	2	2
Singapore	SG	2	2	1	1
Thailand	TH	2	2	2	2
Timor-Leste	TL	2	3	3	2
Vietnam	VN	2	2	2	2

From Table 2, Brunei, Malaysia, and Singapore are located in the group of top-level, while Laos, Cambodia, and Timor-Leste are located in the group of low-level. From the perspective of benchmarking, the low-level group can learn from the group of top-level.

5. Conclusion

In conclusion, the Entropy-RSR evaluation model we have built represents a valuable tool for enhancing road safety in Southeast Asia and potentially in other regions of the world. The empirical findings generated by this model offer crucial insights that can influence the development of more comprehensive road safety policies and action plans in Southeast Asian countries. By improving road safety, we not only reduce the loss of human life but also relieve the economic burdens caused by traffic accidents. Ultimately, our evaluation framework contributes to the broader goal of enhancing the well-being of people and fostering economic growth. Its reproducible nature makes it a useful template for future safety reviews in various parts of the world, ensuring that our efforts to make roads safer can extend through Southeast Asia. In the region where road safety is an ever-pressing concern, our model provides a step in the right direction toward safer roads and promising futures for those countries.

References

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