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Weighting Criteria Evaluation between ASEAN NCAP and Industry Perception Using Analytic Hierarchy Process

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ABSTRACT – *This study evaluates the weighting criteria for vehicle safety assessments, comparing the perspectives of the automotive industry with those of ASEAN NCAP, using the Analytic Hierarchy Process (AHP). The research aims to identify discrepancies in the prioritization of safety features and explore how these differences may influence vehicle safety standards in Southeast Asia. The analysis revealed significant variations in the ranking of key safety criteria such as Adult Occupant Protection (AOP), Child Occupant Protection (COP), and Safety Assist (SA). While ASEAN NCAP places a higher priority on foundational safety elements like AOP, the industry tends to prioritize advanced technologies, particularly within the SA category. These findings suggest a need for closer alignment between industry practices and regulatory frameworks to enhance overall vehicle safety. The study's insights are crucial for informing policy decisions and improving the effectiveness of safety regulations, thereby contributing to reduced fatalities and injuries on the roads in Southeast Asia.*

KEYWORDS: Adult Occupant Protection (AOP), Child Occupant Protection (COP), safety assist, Analytic Hierarchy Process (AHP)

1. INTRODUCTION

Launched in 2011, the New Car Assessment Program for Southeast Asian Countries (ASEAN NCAP) has become a driving force for safer roads in the region. Through rigorous crash tests and clear safety ratings, ASEAN NCAP empowers consumers with the knowledge to choose vehicles that prioritize passenger protection. This has pushed manufacturers to up their game, leading to a marked improvement in the safety features and overall standards of cars available in Southeast Asia (Kassim et al., 2017). More than just a rating system, ASEAN NCAP's impact goes beyond ratings; it's a catalyst for a safer motoring culture, fostering consumer confidence and well-being. This commitment to progress is further solidified by the 2021-2025 Roadmap, a blueprint for further elevating regional road safety. The ASEAN NCAP Roadmap 2021-2025 Calculation Table in Figure 1 outlines the weightage for each area of assessment in the ASEAN NCAP rating system. The 2021-2025 Roadmap marks a decisive shift in gear for ASEAN NCAP's safety push. Compared to its predecessor, the new calculation table sets a tougher pace for manufacturers. Stringency takes center stage, with stricter test protocols, higher minimum star rating requirements, and a brand-new focus on protecting vulnerable motorcyclists (Jawi et al., 2016; Khalid et al., 2021).

The AHP is a structured technique for organizing and analyzing complex decisions, based on mathematics and psychology. Developed by Thomas L. Saaty in the 1970s, AHP has been extensively studied and refined since then (Stofkova et al., 2022). It represents an accurate approach to quantifying the weights of decision criteria and has been applied in various fields, including the automotive industry.

AHP can effectively identify priorities, and screen and consolidate alternatives in large nominal groups. This results in a reduced set of alternatives and improved decision-making (Armacost et al., 1999). In the automotive industry, AHP has been used in studies such as human factor in automotive (Petruni et al., 2019). In the context of effective vehicle design, AHP is utilized to determine the most effective concept phases for new automotive products. This aids in prioritization and decision-making within the vehicle design process (Paker et al., 2018). Furthermore, AHP has been utilized in safety feature prioritization. It plays a crucial role in ensuring every car prioritizes passenger well-being. A recent study by Aziz et al. (2021) demonstrates its potential in the ASEAN NCAP rating system. AHP was used to prioritize body regions based on injury severity in frontal crashes. This helps manufacturers focus on safety features where they matter most (Sukadarin et al., 2020).

This research aims to create and implement a robust research instrument for assessing the relative importance of different criteria within the ASEAN NCAP rating system. Utilizing the AHP, the study will gather data from key stakeholders within the automotive industry, specifically focusing on their perspectives on the weighting of various pillars and individual items within the rating assessment. By analyzing the collected data through AHP, we will then strive to determine the most accurate and representative weighting values for each element, ultimately refining the ASEAN NCAP system and potentially optimizing its impact on vehicle safety in Southeast Asia.

ASEAN NCAP www.aseancap.org 2021-2025	AOP		COP		Safety Assist		Motorcyclist Safety	
	Item	Max	Item	Max	Item	Max	Item	Max
	Frontal	16	Frontal	16	*EBA*	6	*BSD / BSV*	8
	Side	8	Side	8	*SBR(Fr.)*	3	*Rear View Technology*	4
	HPT Evaluation	8	CRS Installation	12	*SBR(Rr.)*	1.5	*AHB*	2
			Vehicle Based Assessment	13	*SBR(Rr.) Advanced*	1.5	Pedestrian Protection	2
			Child Presence Detection	2	*AEB City*	2.5		
					AEB Inter Urban	3.5	*[Advanced MST]**	2*
					Advanced SAT	3	**BONUS POINT*	
Score		32		51		21		16
Weighting		40%		20%		20%		20%

Slanting = Fitment Rating System   ** To add 2 points MAX to total MS point*

	AOP (%)	COP (%)	Safety Assist (%)	Motorcyclist Safety (%)
5 ★	80	75	70	50
4 ★	70	60	50	40
3 ★	60	30	40	30
2 ★	50	25	30	20
1 ★	40	15	20	10

FIGURE 1: ASEAN NCAP Roadmap 2021-2025 (Khairil Anwar Abu Kassim et al., 2018)

2. METHODOLOGY

This study focuses on meticulous data collection to compare and understand the perspectives of ASEAN NCAP and the automotive industry on vehicle safety ratings. The research unfolds in three key stages. The first stage involves survey development based on the pillar and item in the ASEAN NCAP Rating. In the second stage, the survey is distributed to the automotive industry respondents, possibly through Google Forms, and additional data is gathered through interviews. The respondent is expected to have an in-depth understanding of automotive safety. To understand the opinion of the automotive industry, this study included people related to the automotive safety department. Twenty-four respondents were involved in this research. The respondents were between 22 to 50 years old. Only 33.3% of the respondents fell in the age group of above 39. The respondents were mostly male in the gender category (79.17%). The final stage involves analyzing the results using AHP (Vafaei et al., 2016).

2.1 Data Analysis Using AHP

Generally, implementing AHP is based on the knowledge of experts or users to determine the factors affecting the decision-making process (Ariff et al., n.d.). In addition, it provides a methodology to calibrate the numeric scale for the measurement of quantitative as well as qualitative performances (Vaidya & Kumar, 2006). The hierarchy's weights were a deciding factor on the elements' relative significance and preferences. A pair-wise comparison is obtained when comparing two things directly. The preference scale is in Table 1. The values in each column of the related matrices were then added, and the total was divided by the number of rows in the pair-wise comparison matrix to normalize it.

$$\bar{a}_{jk} = \frac{a_{jk}}{\sum_{l=1}^{m} a_{lk}}$$

Add up all the columns in a row from the matrix's comparative normalization result to determine the synthesis weight.

$$\Sigma \text{ column} = k1 + k2 + k3 + \ldots + kn$$

Consequently, calculate the eigenvalues by multiplying each matched matrix column in the same row, then being lifted by an existing criterion number.

$$\lambda_1 = (k1 \times k2 \times k3 \times \ldots \times kn)^{\frac{1}{n}}$$

The relative importance of each criterion is then determined by dividing the sum of all eigenvalues by the number of criteria. The relevance of each criterion is calculated using this method by dividing the priority weight by the synthesis weight. The highest eigenvalue (max) is then obtained by dividing the total number of important values by the total number of criteria. Additionally, it verifies the accuracy of the application to ensure accurate judgment while making crucial decisions.

$$CI = \frac{(\lambda_{max} - n)}{n}$$

where: **CI** = Consistency Index, $\boldsymbol{\lambda}_{\mathbf{max}}$ = Maximum eigenvalue, **n** = Number of elements

The hierarchy should then be checked for consistency, with the condition that if the Consistency Ratio (CI/IR) is less than or equal to 0.1, the calculation's conclusion is deemed to be correct.

$$\mathbf{CR} = \frac{\mathbf{CI}}{\mathbf{RI}}$$

where: **CR** = Consistency Ratio **CI** = Consistency Index **RI** = Index Random Consistency.

The hierarchy is illustrated in Figure 2 including the acronym for each criterion and alternatives while the preference scale is in Table 1 and Index Random Consistency is as shown in Table 2. At the top of the hierarchy in Level 1, the goal of decision-making is set. The main goal is supported by a sub-goal, known as criteria, at Level 2, meanwhile, Level 3 is the alternative.

TABLE 1: Preference scale of AHP technique

Preference	Numerical Rating
Extremely more important	9
Very strongly more important	7
Strongly more important	5
Moderately more important	3
Equally Important	1

TABLE 2: Index Random Consistency (Shyamprasad & Kousalya, 2020)

Matrix Size	19	20	21	22	23	24	25	26
RI	1.62	1.63	1.63	1.64	1.65	1.65	1.66	1.66

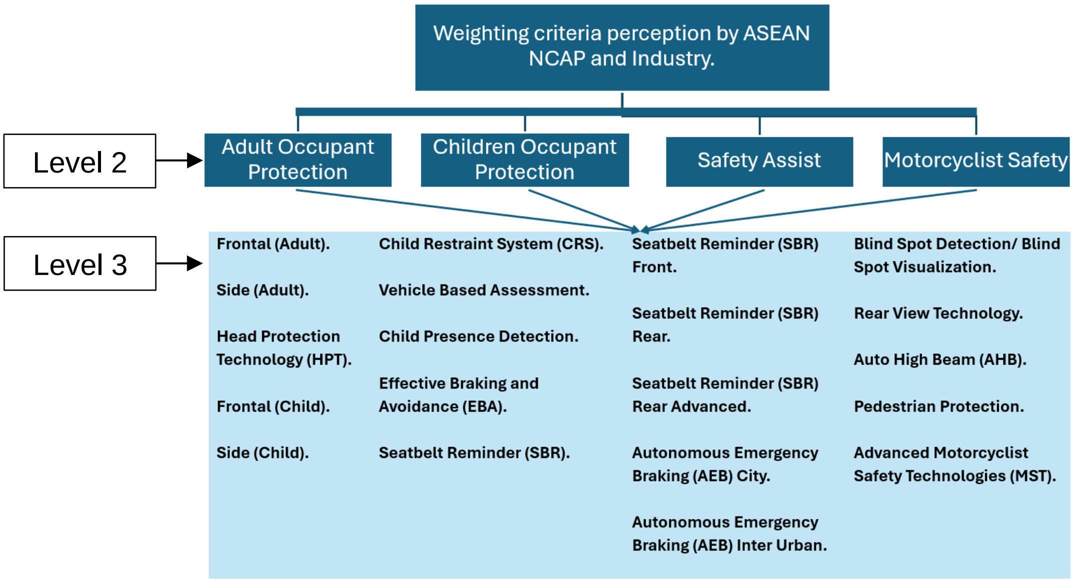

FIGURE 2: Hierarchy framework

3. RESULTS AND DISCUSSION

The Consistency Ratio (CR) of a reliable individual should be far lower than the value produced by a random set of entries. The CR value is a crucial metric in research. Note that a higher CR value indicates greater internal consistency among measured variables. The CR value is 0.7, A CR value of 0.7 and above is generally considered acceptable in most research contexts, indicating satisfactory internal consistency. The weights are determined through a process of pairwise comparisons as shown in Table 3 and the synthesized matrix in Table 4.

The results presented in Table 5 and Figure 3 highlight the overall priority vectors for various vehicle safety criteria, comparing perspectives from the automotive industry and the ASEAN NCAP ratings. The evaluated criteria include Adult Occupant Protection (AOP), Child Occupant Protection (COP), Safety Assist (SA), and Motorcyclist Safety (MST). Each criterion is assigned a weight and ranked according to the industry's priorities and ASEAN NCAP. AOP presents a notable divergence between the two perspectives. The industry ranks AOP as the least critical of the four criteria, placing it 4th, despite its significance in the ASEAN NCAP ratings, where it is considered the most important, ranking 1st. This discrepancy suggests that, while the industry recognizes the importance of AOP, other factors might be prioritized due to considerations such as cost, technological focus, or market demands. On the other hand, ASEAN NCAP's ranking underscores the essential role of AOP in consumer safety and regulatory frameworks, indicating that the industry may need to align more closely with these regional safety standards to enhance overall vehicle safety.

In contrast, there is a clear consensus on the importance of COP. Both the industry and ASEAN NCAP rank COP as the 2nd most critical criterion, reflecting a shared commitment to improving child safety in vehicles. The significant weight attributed to COP by both parties further emphasizes its importance, showcasing a unified approach to advancing child safety measures, which is a critical focus for both manufacturers and regulatory bodies. SA is ranked as the highest priority by the industry, a reflection of the growing emphasis on advanced driver assistance systems (ADAS) and their role in preventing accidents. However, ASEAN NCAP ranks SA slightly lower, assigning it a shared 2nd rank along with other criteria. This suggests that, while the industry views SA as a crucial factor, ASEAN NCAP considers it within a broader context of vehicle safety features. This difference in prioritization may indicate the industry's focus on cutting-edge technologies, whereas ASEAN NCAP adopts a more holistic view of safety.

The MST rank shows a close alignment between the industry and ASEAN NCAP, with the industry placing it 3rd and ASEAN NCAP ranking it 2nd. This similarity reflects a mutual recognition of the need to enhance safety for motorcyclists, a critical concern in many ASEAN countries where motorcycle use is prevalent. The industry's slightly lower ranking may reflect the challenges of integrating effective MST measures into vehicle design, but the overall high ranking by both parties indicates its importance in the region's safety priorities. In summary, while there are areas of agreement between the industry and ASEAN NCAP, particularly in the rankings of Child Occupant Protection and Motorcyclist Safety, differences in the prioritization of Adult Occupant Protection and Safety Assist reveal varying focuses that may be influenced by technological advancements, regulatory pressures, and market demands. Bridging these differences could result in more comprehensive safety strategies that better protect all road users.

TABLE 3: Pair-wise comparison from industry perceptive

	AOP	COP	SA	MST
AOP	1	2.962	2.309	2.589
COP	0.338	1	1.120	2.532
SA	0.433	0.893	1	3.305
MST	0.386	0.395	0.303	1
	2.157	5.250	4.732	9.426

TABLE 4: Synthesized matrix for the overall goal from industry perspective

	AOP	COP	SA	MST
AOP	0.464	0.564	0.488	0.275
COP	0.157	0.19	0.237	0.269
SA	0.201	0.17	0.211	0.351
MST	0.179	0.075	0.064	0.106
	1	1	1	1

TABLE 5: Overall priority vector for criteria from

Item		Industry		ASEAN NCAP	
		Weightage	Rank	Weightage	Rank
AOP	Adult Occupant Protection	14.2	4	40	1
COP	Child Occupant Protection	24.8	2	20	2
SA	Safety Assist	36.0	1	20	2
MST	Motorcyclist Safety	25.0	3	20	2

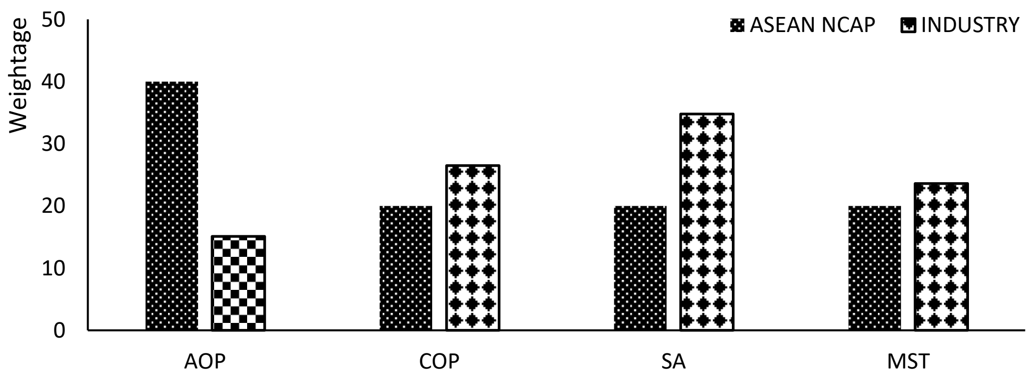

FIGURE 3: Priority vector of criteria between ASEAN NCAP and Industry perceptions

The results presented in Table 6 highlight the prioritization of various vehicle safety features, emphasizing the significance of preventive and protective measures. The Seatbelt Reminder (Front) feature stands out with the highest weight of 0.063 and is ranked 1st, indicating it as the most critical safety feature in this evaluation. This is followed closely by Blind Spot Detection/Blind Spot Visualization, which, with a weight of 0.054, is ranked 2nd. The Side (Child) Protection feature also ranks high, placed 3rd with a weight of 0.052, reflecting its crucial role in child safety during side impacts. Features such as Effective Braking and Avoidance (EBA) and Child Restraint System Installation are similarly highly prioritized, ranked 4th and 5th respectively, each with a weight of 0.052. Conversely, features like Frontal (Adult), Pedestrian Protection, and Child Presence Detection are ranked much lower, indicating they are considered less critical relative to other safety features, with ranks of 19th, 18th, and 20th, respectively.

The top-ranking of the Seatbelt Reminder (Front) feature underscores its fundamental role in ensuring occupant safety. The high weight attributed to this feature reflects its direct impact on reducing fatalities and injuries in the event of a collision. The prioritization of Blind Spot Detection/Blind Spot Visualization as the second most important feature highlights the growing emphasis on technologies that prevent accidents before they occur, particularly in situations where visibility is compromised. The strong ranking of Side (Child) Protection at 3rd place emphasizes the critical need for robust child protection systems in side impact scenarios. This high ranking suggests that manufacturers and safety organizations place considerable importance on the safety of child occupants, particularly in regions where side impacts are common. In contrast, the relatively low rankings of Frontal (Adult) and Pedestrian Protection may reflect a perceived adequacy in existing frontal protection measures or a greater focus on emerging technologies that address other areas of vulnerability.

The last-ranked Child Presence Detection feature, despite its importance in preventing child heatstroke deaths, indicates that it is either not yet widely implemented or considered less critical compared to other safety features, possibly due to the focus on more immediate collision-prevention technologies. The middle-ranking features, such as Effective Braking and Avoidance (EBA) and Child Restraint System Installation, illustrate the balanced approach to safety that incorporates both proactive and protective measures. These features are crucial in both preventing accidents and mitigating their impact when they occur, indicating their relevance in a comprehensive vehicle safety strategy. Overall, the rankings in Table 6 reflect a balanced consideration of both preventive and protective safety technologies, with a notable emphasis on features that directly enhance occupant safety during a collision. This analysis suggests that while traditional safety features remain important, there is a growing focus on advanced technologies that can prevent accidents and protect vulnerable road users, such as children. The industry’s focus on these features is likely influenced by advancements in technology, regulatory requirements, and the evolving understanding of accident causation and prevention.

The results in Figures 4, 5, and 6 provide a comparative analysis of the priority vectors assigned to various safety criteria by the automotive industry and ASEAN NCAP. These figures illustrate the differences in ranking and emphasis placed on Adult Occupant Protection (AOP), Child Occupant Protection (COP), and Safety Assist (SA) technologies, as well as other critical safety features. Figure 4 compares the priority vectors for AOP and COP. The industry and ASEAN NCAP exhibit significant differences in their rankings. AOP is given lower priority by the industry compared to ASEAN NCAP, which ranks it as one of the top safety criteria. This discrepancy highlights a potential area where industry priorities may diverge from regulatory or consumer safety concerns. Conversely, COP is consistently ranked highly by both parties, indicating a shared recognition of the importance of protecting child occupants in vehicles. The alignment on COP suggests that both the industry and ASEAN NCAP prioritize child safety as a critical aspect of vehicle design and evaluation.

The Safety Assist (SA) results in Figure 5, reveal further discrepancies between the industry and ASEAN NCAP perspectives. The industry places substantial emphasis on advanced driver assistance systems (ADAS) under the SA category, prioritizing features like Effective Braking and Avoidance (EBA) and various seatbelt reminders. These features are crucial in preventing accidents and ensuring occupant safety, reflecting the industry's focus on proactive safety measures. ASEAN NCAP also values these technologies but tends to rank them slightly lower than the industry, possibly due to a more balanced consideration of all safety aspects, including traditional and emerging technologies.

Figure 6 expands the comparison to include a broader range of safety features, such as Blind Spot Detection, Rear View Technology, and Pedestrian Protection. The industry prioritizes technologies like Blind Spot Detection and Rear View Technology more highly, emphasizing the prevention of accidents through enhanced driver awareness and visibility. ASEAN NCAP, while still recognizing the importance of these features, places more balanced importance across a wider array of safety technologies. The lower ranking of Pedestrian Protection by the industry compared to ASEAN NCAP may reflect differing regional safety concerns or the industry's focus on in-vehicle occupant protection over external safety measures.

In conclusion, the comparison between industry perspectives and ASEAN NCAP ratings across these figures highlights both alignments and divergences in safety priorities. While there is a consensus on the importance of Child Occupant Protection and some advanced safety assist technologies, discrepancies in the prioritization of Adult Occupant Protection, Pedestrian Protection, and other features suggest differing focuses that may be influenced by technological capabilities, regulatory frameworks, and market demands. Bridging these gaps could lead to more comprehensive safety strategies that better protect all road users, aligning industry innovations more closely with regulatory and consumer expectations.

TABLE 6: Overall priority vector for alternatives

	Item	Weights	Rank
1	Frontal (Adult)	0.045	19
2	Side (Adult)	0.048	14
3	Head Protection Technology (HPT) Evaluation	0.049	13
4	Frontal (Child)	0.049	11
5	Side (Child)	0.052	3
6	Child Restraint System Installation	0.052	5
7	Vehicle-Based Assessment	0.050	9
8	Child Presence Detection	0.045	20
9	Effective Braking and Avoidance (EBA)	0.052	4
10	Seatbelt Reminder (Front)	0.063	1
11	Seatbelt Reminder (Rear)	0.051	8
12	Seatbelt Reminder (Rear) Advanced	0.047	17
13	Autonomous Emergency Brake (City)	0.049	12
14	Autonomous Emergency Brake (Inter-Urban)	0.047	16
15	Advanced Safety Assist Technologies	0.051	7
16	Blind Spot Detection/ Blind Spot Visualization	0.054	2
17	Rear View Technology	0.051	6
18	Auto High Beam	0.048	15
19	Pedestrian Protection	0.046	18
20	Advanced Motorcyclist Safety Technology	0.050	10

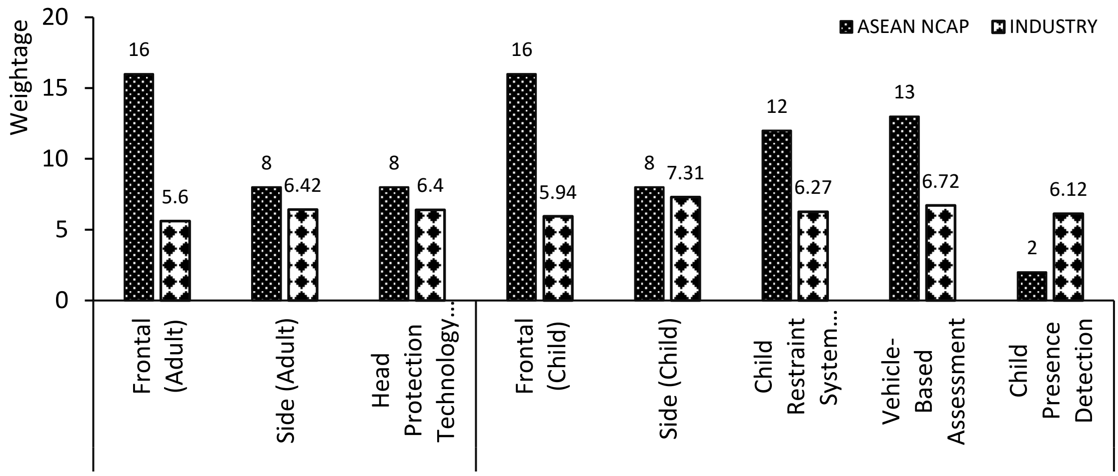

FIGURE 4: Comparison of the priority vector of AOP and COP

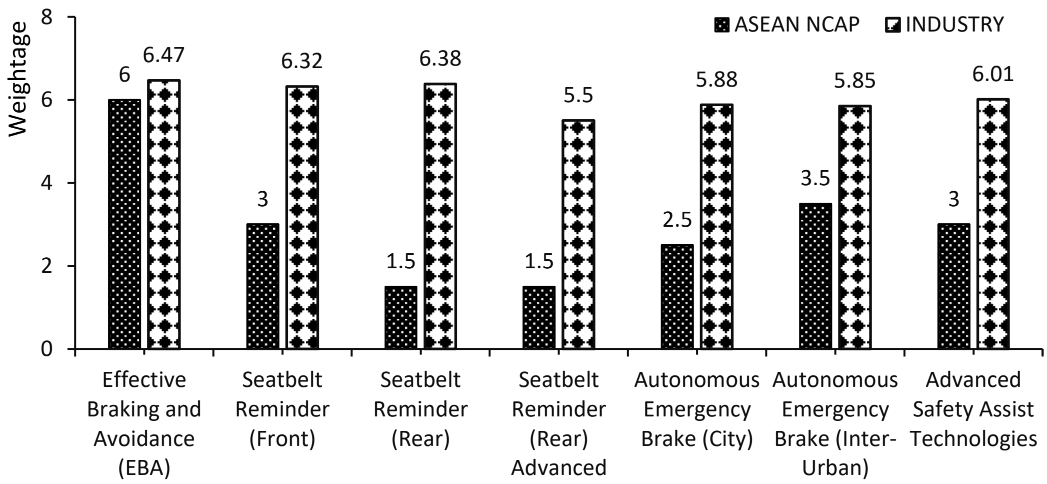

FIGURE 5: Comparison priority vector of SA

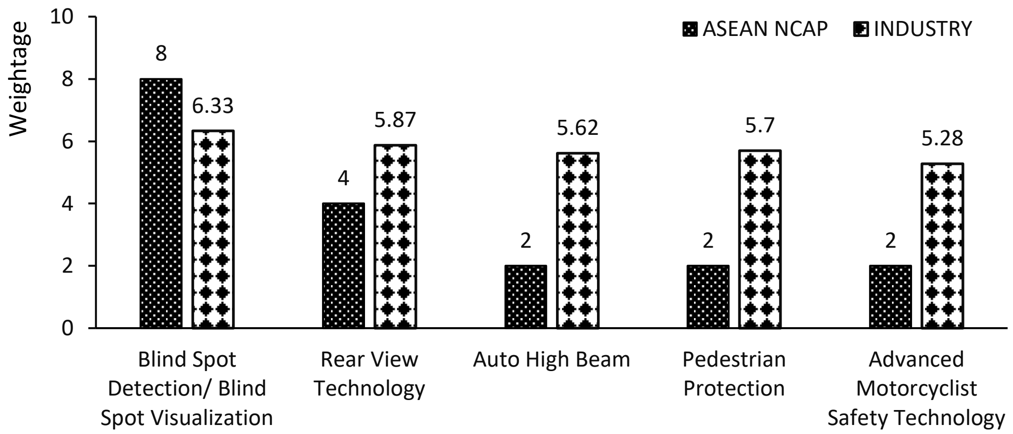

FIGURE 6: Comparison priority vector of SA

5. CONCLUSION

This research employed the Analytic Hierarchy Process (AHP) to uncover significant disparities in car safety rating priorities between the automotive industry and ASEAN NCAP. While ASEAN NCAP emphasizes fundamental safety elements like Adult Occupant Protection (AOP), the automotive industry tends to prioritize technological advancements, particularly in Safety Assist (SA) technologies. This divergence underscores the need for collaborative efforts to refine car safety rating systems in alignment with the ASEAN NCAP Roadmap 2021-2025, which highlights the importance of technological innovation. Precise data and thorough research are essential in this endeavor, as is the acknowledgment of the critical role that driver behavior plays in the effectiveness of safety programs.
It is recommended that future research focus on a small, specialized group of experts, such as car design engineers, crash test engineers, and homologation engineers, who possess in-depth knowledge of accident test outcomes and injury severity. Their insights could be instrumental in refining safety evaluations. Additionally, stricter enforcement of safety technology regulations for both cars and motorcycles is vital for reducing accident rates in Malaysia. Given this, safety ratings should take precedence over other factors in determining the ASEAN NCAP star rating. Ultimately, promoting robust safety standards in Southeast Asia requires a balanced approach that integrates both advanced technologies and traditional safety measures, informed by data-driven decisions and responsible driver behavior. This study highlights the discrepancies in safety feature prioritization between the automotive industry and ASEAN NCAP, emphasizing the need for greater alignment to enhance vehicle safety standards. While technological advancements are crucial, they should not overshadow the importance of fundamental safety features. Aligning industry practices with regulatory priorities, as outlined in the ASEAN NCAP Roadmap 2021-2025, is essential for developing comprehensive safety strategies that protect all road users. Moving forward, collaboration between industry stakeholders and regulatory bodies will be key to ensuring that safety innovations meet both consumer and regulatory expectations, ultimately leading to safer roads across Southeast Asia.

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