

Motor Insurance Policy Selection: A Joint Spherical Fuzzy Analytic Hierarchy Process (SF-AHP) and Combined Compromise Solution (CoCoSo) Approach

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Motor insurance policies play a crucial role in protecting vehicle owners against financial losses due to accidents, theft, or other unforeseen events. The selection of an appropriate motor insurance policy is a complex decision-making process that requires considering multiple criteria and their interrelationships. The motivation behind this study is to offer an advanced decision-making framework that addresses the complexities of motor insurance policy selection, improves risk management, fosters innovation in decision-making methodologies, enhances customer satisfaction, and increases the competitiveness of insurance providers. This research presents a joint approach, combining the SF-AHP (Spherical Fuzzy Analytic Hierarchy Process) and the CoCoSo (Combined Compromise Solution) method, to facilitate the selection of the most suitable motor insurance policy. The weights of the factors are estimated by SF-AHP method with experts' advice. The rankings of the alternatives are calculated using CoCoSo method. The sensitivity analysis is also carried out to check the stability of results over different Eigen values (λ). Premium amount is identified as the most influencing factor with factors weight as 0.178 and reputation of the insurance company is identified as least dominating out of other selected factors with factor weight as 0.10. The results are significantly stable over different λ values ranging from zero to one. The research paper addresses a novel problem of motor insurance policy selection that has not been explored by any previous researchers in the existing literature.

Keywords: Analytic hierarchy process, Fuzzy sets, Multi-criteria decision-making, Ranking, Spherical AHP

Introduction

The Motor insurance is a form of insurance designed to provide financial protection against loss or damage to a vehicle, as well as liability for injuries or property damage caused to third parties. It is a mandatory requirement in many countries and can provide peace of mind for drivers knowing that they are protected in the event of an accident. Numerous varieties of motor insurance coverage exist, each meticulously tailored to safeguard against distinct hazards.¹ Liability coverage is designed to protect against claims made by third parties for injuries or property damage caused by the insured's vehicle. This coverage is mandatory in most jurisdictions and typically includes both bodily injury liability and property damage liability. Collision coverage is designed to provide protection against damage to the insured's vehicle in the event of an accident. This coverage is optional but may be required if the vehicle is financed or leased. Personal injury protection, or PIP, is designed to provide coverage for medical

expenses and lost wages for the insured and their passengers in the event of an accident, regardless of who is at fault. This coverage is mandatory in some jurisdictions.

The cost of motor insurance premiums can be affected by several factors, including driving record, age, vehicle type, and location.² Drivers with a history of accidents or traffic violations are typically considered to be higher risk and may be charged higher premiums. Younger drivers are generally considered to be higher risk and may also be charged higher premiums. Vehicles that are more expensive to repair or replace, or that have a higher likelihood of being stolen, may also result in higher premiums. Additionally, drivers in areas with high rates of accidents or theft may be charged higher premiums.

Having adequate motor insurance coverage is essential for protecting oneself financially in the event of an accident.³ Without insurance, the costs of repairing or replacing a vehicle, as well as liability for injuries or property damage caused to others, can be prohibitively expensive. In addition to financial protection, having motor insurance can also provide peace of mind and help to ensure that drivers are able

to meet their legal obligations. In many jurisdictions, driving without insurance is illegal and can result in fines, license suspension, and even criminal charges.

Challenges in Insurance Policy/Provider Selection

Policy selection can be a challenging process, particularly for individuals who are not familiar with the insurance industry. One of the main challenges in policy selection is understanding the various types of coverage that are available and determining which ones are necessary. For example, liability coverage is mandatory in most jurisdictions, but the amount of coverage required can vary depending on the state or country. Similarly, collision and comprehensive coverage are optional, but may be required if the vehicle is financed or leased. It can be difficult to determine which types of coverage are necessary and how much coverage is needed.

Another challenge in policy selection is determining the level of deductible that is appropriate. Conversely, a lower deductible can result in higher premiums but may be more affordable in the event of an accident.

The cost of insurance premiums is another challenge in policy selection. Insurance premiums can vary significantly depending on the insured's driving record, age, vehicle type, and location.⁴ It can be difficult to determine which policy provides the best value for the price, particularly for individuals who are on a tight budget.

Finally, selecting the right insurance provider can also be a challenge.⁵ There are many insurance companies to choose from, each offering different types of policies and coverage options. It can be difficult to determine which provider is reputable and provides good customer service, particularly for individuals who are not familiar with the insurance industry.

To overcome these challenges, it is important to do research and carefully consider each policy option. This may involve speaking with insurance agents or brokers, reading policy documents carefully, and comparing prices and coverage options from multiple providers. It is also important to consider the potential risks and costs associated with different types of coverage and to choose a policy that provides adequate protection at a price that is affordable. By taking the time to carefully consider each policy option, individuals can select a policy that meets their needs and provides peace of mind.⁶

Why a Joint SF-AHP and CoCoSo Approach?

The joint approach is effective in motor insurance policy selection problem because it can handle

uncertainty in the decision-maker's judgments and generate a compromise solution that is robust to uncertainty. When selecting a motor insurance policy, there are many factors to consider, such as the cost of the policy, the coverage offered, the deductible, and the claims process. The decision-maker may not have all the information they need to make a decision, or they may not be able to accurately assess the importance of the different factors. The joint CoCoSo approach can help the decision-maker to make a more informed decision by allowing them to express their judgments about the importance of the different factors in a fuzzy manner. The approach can also generate a compromise solution that is robust to uncertainty, which means that the solution is not sensitive to changes in the decision-maker's judgments or the information that is available. This makes it a valuable tool for motor insurance policy selection problem. Here are some of the benefits of using a joint approach in motor insurance policy selection:

- It can help the decision-maker to make a more informed decision by allowing them to express their judgments about the importance of the different factors in a fuzzy manner.
- It can generate a compromise solution that is robust to uncertainty, which means that the solution is not sensitive to changes in the decision-maker's judgments or the information that is available.
- It is relatively easy to implement and computationally efficient.

Literature Review

The systems are designed to aid decision-makers in addressing intricate decision-making challenges across various sectors. The development of the decision support systems reflects the ongoing efforts to provide effective solutions for complex decision-making problems in diverse fields of study and industries.

The problem of motor insurance policy selection is comparatively new. Few researches have focused on health insurance policy selection.⁷⁻⁹ Motor insurance policy selection is a multifaceted process with many alternatives and criteria. Hesitant fuzzy linguistic models can help decision makers make more accurate choices.

AHP is a widely used MCDM method that allows decision-makers to break down a complex decision into a hierarchy of criteria and alternatives, and then

compare the alternatives against each criterion using pairwise comparisons. Spherical fuzzy sets are a type of fuzzy set that allows for the representation of uncertainty and hesitancy in decision-making. The SF-AHP method has been used in a variety of applications, including project selection, facility location, supplier selection etc.

The SF-AHP method was able to effectively handle the uncertainty and hesitancy that was present in the decision-making process.^{10,11} The SFAHP is utilized to determine the importance levels of criteria that influence employee retention and to evaluate the impact of various types of career management activities on employee retention.¹² Validation of SF-AHP was carried out in industrial robot selection problem.¹³ A novel hybrid MCDM model that combines the SF-AHP and the CoCoSo Algorithm is available in the scarcely in the literature.¹⁴⁻¹⁶

The authors conducted a process of selecting logistics and transportation companies in France as part of a broader supply chain project.¹⁷ In this endeavor, they applied fuzzy SWARA and CoCoSo methods to address the location selection challenge for a logistics center.¹⁸ To assess and rank each supplier according to predefined criteria, the CoCoSo-G method was employed.¹⁹ The primary objective was to use this approach for supplier evaluation and ranking, and the results obtained were subsequently compared to those generated by the Complex Proportional Assessment method. This comparison aimed to gauge the effectiveness and performance of the CoCoSo-G method in supplier evaluation and

ranking when juxtaposed with an alternative method like Complex Proportional Assessment.

Research Gaps

1. A primary gap for conducting this research is non availability of studies related to motor insurance policy selection. Numbers of studies are available in health insurance policy domain. But the requirements of motor insurance are different.
2. Another potential knowledge gap for this research paper could be the lack of investigation into the practical application and comparative effectiveness of the proposed joint SF-AHP and CoCoSo approach in real-world motor insurance policy selection scenarios. While the paper introduces a novel methodology for addressing the policy selection problem, there may be a need for empirical studies or case studies to demonstrate its performance, robustness, and efficiency in various insurance contexts.

Methodology

The selection of a motor insurance policy is a crucial decision with significant financial implications. Making the right choice is essential to avoid potential losses. However, this decision-making process involves both quantitative and qualitative criteria, which adds complexity. To address this complexity, fuzzy set theory is often incorporated into MCDM models. This integration allows for the consideration of the ambiguity inherent in the decision-making process. The flowchart depicting the research methodology employed in the study is provided in Fig. 1.

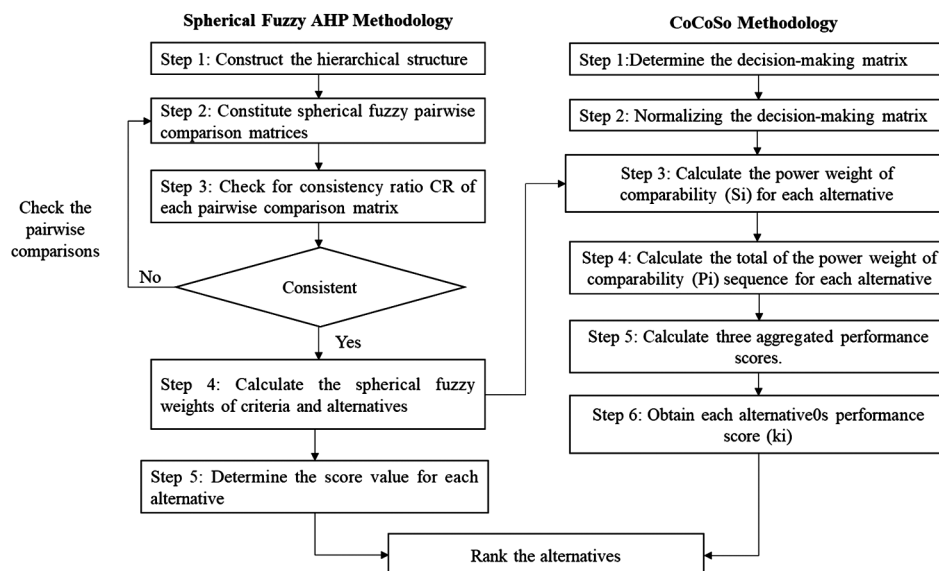


Fig. 1 — Research methodology

Table 1 — Details of factors identified

Criteria	Criteria Type	Description
Premium amount (C1)	Minimization	Premium amount in motor insurance policy is the amount of money that you pay to the insurance company in exchange for coverage. The premium amount is determined by a number of factors, including the make and model of your car, your driving history, and the coverage that you choose.
IDV cover (C2)	Maximize	IDV Cover, also known as Insured Declared Value (IDV) Cover, is a type of motor insurance coverage that reimburses you for the full market value of your car in the event of a total loss.
Free add-on (C3)	Maximize	An add-on in motor insurance is an additional coverage that you can purchase to supplement your basic policy. Add-ons can provide coverage for a variety of risks, such as theft, vandalism, and roadside assistance.
Reputation of the insurance company (C4)	Maximize	The reputation of an insurance company is important to consider when choosing a policy. A reputable company is more likely to pay your claims promptly and fairly, and to provide good customer service.
Claim settlement ratio (C5)	Maximize	Claim settlement ratio (CSR) is a percentage of claims that an insurance company settles in a year out of the total claims received. It is used to assess the company's credibility. In general, the higher the ratio, the more reliable the insurer.
After sales support (C6)	Maximize	After-sales service is an important part of customer satisfaction. A good after-sales service can help to build customer loyalty and encourage repeat business. It can also help to improve the company's reputation.
No of cashless garages (C7)	Maximize	It refers to number of garages associated with insurance service provider having cashless facility.

Spherical Fuzzy Sets (SFS)

Fuzzy sets have gained prominence in the field of decision-making as a tool to handle uncertainties. Within this context, the spherical fuzzy Sets have captured the attention of researchers. It represents an extension of fuzzy sets that incorporates Pythagorean Fuzzy Sets (PFS) and Neutrosophic sets.²⁰⁻²² By utilizing SFS, decision-makers are empowered to express their uncertain opinions through specific settings and parameters.

Results and Discussion

In the present study, motor insurance policy selection problem is handled. A discussion was held with a group of three experts, including two academic experts and one industry expert in hybrid mode. Through literature review and expert opinions, initially thirteen factors were identified. Through discussion seven significant factors are shortlisted (Table 1).

The linguistic measures which are used to form Spherical Fuzzy Pairwise Comparison Matrix are given in Table 2.

The SF-AHP was applied to calculate the weights of seven criteria. The data in Table 3 shows the Spherical Fuzzy Pairwise Comparison Matrix. The result of aggregated evaluations obtained from decision makers is shown in Table 4. The final outcomes of this analysis are presented in Table 5,

Table 2 — Linguistic measures of importance

Definition	(μ, ν, π)	Score Index (SI)
Absolutely more importance (AM)	(0.9, 0.1, 0.0)	9
Very high importance (VH)	(0.8, 0.2, 0.1)	7
High importance (HI)	(0.7, 0.3, 0.2)	5
Slightly more importance (SM)	(0.6, 0.4, 0.3)	3
Equally importance (EI)	(0.5, 0.4, 0.4)	1
Slightly lower importance (SL)	(0.4, 0.6, 0.3)	1/3
Low importance (LI)	(0.3, 0.7, 0.2)	1/5
Very low importance (VL)	(0.2, 0.8, 0.1)	1/7
Absolutely low importance (AL)	(0.1, 0.9, 0.0)	1/9

providing valuable insights into the relative importance and significance of each criterion within the decision-making framework. The rankings of the alternatives were also obtained.

The CoCoSo algorithm is then applied to determine the ranking of insurance service providers. This algorithm takes into account the normalized matrix, as well as the weighted comparability sequence (Si) and exponentially weighted comparability sequence (Pi). The corresponding values for these parameters are presented in Tables 6, Table 7, and Table 8.

The normalized matrix provides a comprehensive view of the relative performance of each alternative in relation to the established criteria (Table 7). The weighted comparability sequence (Si) in Table 7

Table 3 — Spherical fuzzy pairwise comparison matrix

	Expert 1							Expert 2							Expert 3						
	C1	C2	C3	C4	C5	C6	C7	C1	C2	C3	C4	C5	C6	C7	C1	C2	C3	C4	C5	C6	C7
C1	EI	SM	SM	HI	SM	SM	HI	EI	SM	HI	HI	SM	SM	HI	EI	SM	HI	HI	SM	SM	HI
C2	SL	EI	SM	SM	SM	SM	HI	SL	EI	HI	HI	HI	HI	SL	EI	SM	HI	SM	SM	SM	HI
C3	SL	SL	EI	SM	SM	SL	SM	LI	LI	EI	HI	LI	SL	SL	LI	SL	EI	HI	LI	SL	SL
C4	LI	SL	SL	EI	SL	SL	LI	LI	LI	LI	EI	LI	SL	SL	LI	LI	LI	EI	SL	SL	LI
C5	SL	SL	SL	SM	EI	HI	SM	SL	LI	HI	HI	EI	HI	HI	SL	SL	HI	SM	EI	HI	HI
C6	SL	SL	SM	SM	LI	EI	SL	SL	LI	SM	SM	LI	EI	SL	SL	SM	SM	LI	EI	SL	SL
C7	LI	LI	SL	HI	SL	SM	EI	LI	LI	SM	SM	LI	SM	EI	LI	LI	SM	HI	LI	SM	EI

Table 4 — Aggregated evaluations of the decision makers

	C1		C2		C3		C4		C5		C6		C7								
C1	0.50	0.40	0.40	0.60	0.40	0.30	0.66	0.34	0.24	0.70	0.30	0.20	0.60	0.40	0.30	0.60	0.40	0.30	0.70	0.30	0.20
C2	0.40	0.60	0.30	0.50	0.40	0.40	0.63	0.37	0.27	0.66	0.34	0.24	0.63	0.37	0.27	0.63	0.37	0.27	0.70	0.30	0.20
C3	0.40	0.60	0.30	0.36	0.64	0.27	0.50	0.40	0.40	0.66	0.34	0.24	0.38	0.63	0.23	0.40	0.60	0.30	0.46	0.55	0.30
C4	0.30	0.70	0.20	0.33	0.67	0.23	0.33	0.67	0.23	0.50	0.40	0.40	0.36	0.64	0.27	0.40	0.60	0.30	0.36	0.64	0.27
C5	0.40	0.60	0.30	0.36	0.64	0.27	0.58	0.44	0.25	0.63	0.37	0.27	0.50	0.40	0.40	0.70	0.30	0.20	0.66	0.34	0.24
C6	0.40	0.60	0.30	0.36	0.64	0.27	0.60	0.40	0.30	0.60	0.40	0.30	0.30	0.70	0.20	0.50	0.40	0.40	0.40	0.60	0.30
C7	0.30	0.70	0.20	0.30	0.70	0.20	0.52	0.48	0.30	0.66	0.34	0.24	0.33	0.67	0.23	0.60	0.40	0.30	0.50	0.40	0.40

Table 5 — Results from the SF-AHP model

Criteria	Spherical fuzzy weights			Defuzzified values	Crisp weights
	Membership	Non-membership	Degree of hesitancy		
C1	0.631	0.360	0.279	17.541	0.178
C2	0.609	0.384	0.282	16.867	0.171
C3	0.470	0.523	0.298	12.623	0.128
C4	0.377	0.608	0.285	9.871	0.100
C5	0.573	0.425	0.279	15.783	0.160
C6	0.472	0.520	0.306	12.631	0.128
C7	0.492	0.507	0.284	13.349	0.135

Table 7 — Weighted comparability sequence and Si value

	C1	C2	C3	C4	C5	C6	C7	Si
A1	0.178	0.010	0.064	0.050	0.152	0.128	0.006	0.588
A2	0.130	0.029	0.000	0.000	0.000	0.000	0.029	0.189
A3	0.128	0.000	0.000	0.050	0.154	0.064	0.053	0.449
A4	0.115	0.076	0.064	0.000	0.155	0.064	0.082	0.557
A5	0.086	0.069	0.000	0.100	0.146	0.128	0.006	0.535
A6	0.053	0.069	0.000	0.100	0.151	0.128	0.000	0.501
A7	0.053	0.053	0.000	0.000	0.156	0.064	0.135	0.461
A8	0.034	0.091	0.128	0.100	0.160	0.128	0.018	0.658
A9	0.000	0.171	0.064	0.050	0.160	0.064	0.076	0.586
A10	0.000	0.042	0.000	0.000	0.159	0.000	0.065	0.265

Table 6 — Normalized input decision matrix

Alternatives	Criteria						
	C1	C2	C3	C4	C5	C6	C7
A1	1.000	0.056	0.500	0.500	0.953	1.000	0.043
A2	0.733	0.171	0.000	0.000	0.000	0.000	0.217
A3	0.721	0.000	0.000	0.500	0.963	0.500	0.391
A4	0.644	0.446	0.500	0.000	0.971	0.500	0.609
A5	0.486	0.404	0.000	1.000	0.912	1.000	0.043
A6	0.298	0.404	0.000	1.000	0.943	1.000	0.000
A7	0.297	0.313	0.000	0.000	0.973	0.500	1.000
A8	0.189	0.533	1.000	1.000	0.999	1.000	0.130
A9	0.002	1.000	0.500	0.500	1.000	0.500	0.565
A10	0.000	0.244	0.000	0.000	0.994	0.000	0.478

represents the power weight of comparability for each alternative, indicating their individual suitability for the decision-making process. Furthermore, exponentially weighted comparability sequence (Pi), illustrating the cumulative power weight of comparability for each alternative is given in Table 8. The final aggregation and ranking is presented in Table 9. Ranks are calculated based on the relative

performance scores of the i^{th} alternative calculated as the arithmetic mean of sums of S_i and P_i scores (Ka), sum of relative scores of S_i and P_i scores in comparison to the ideal performance values (Kb), and relative performance scores of the i^{th} alternative calculated as the compromise of S_i and P_i performance scores (Kc).

By utilizing the CoCoSo Algorithm in conjunction with these tables, the research ensures a systematic and objective approach to ranking. This integrated methodology allows for a thorough evaluation, considering both individual and cumulative weights, thus enabling informed decision-making in selecting the most suitable service provider.

In the final phase, an aggregated multiplication rule is applied to produce the ranking of the options and conclude the decision-making process. According to the results presented in Table 9, it is clear that

Table 8 — Exponentially weighted comparability sequence and Pi values

	C1	C2	C3	C4	C5	C6	C7	Pi
A1	1.000	0.611	0.915	0.933	0.992	1.000	0.654	6.106
A2	0.946	0.739	0.000	0.000	0.000	0.000	0.813	2.499
A3	0.944	0.000	0.000	0.933	0.994	0.915	0.881	4.666
A4	0.925	0.871	0.915	0.000	0.995	0.915	0.935	5.557
A5	0.880	0.857	0.000	1.000	0.985	1.000	0.654	5.376
A6	0.806	0.857	0.000	1.000	0.991	1.000	0.000	4.653
A7	0.806	0.820	0.000	0.000	0.996	0.915	1.000	4.537
A8	0.744	0.898	1.000	1.000	1.000	1.000	0.759	6.401
A9	0.343	1.000	0.915	0.933	1.000	0.915	0.926	6.032
A10	0.000	0.786	0.000	0.000	0.999	0.000	0.905	2.690

Table 9 — Final aggregation and ranking

	Ka	Rank	Kb	Rank	Kc	Rank	Ki	Rank
A1	0.1256	2	5.5548	2	0.9482	2	3.0808	2
A2	0.0504	10	2.0000	10	0.3808	10	1.1478	10
A3	0.0960	7	4.2459	8	0.7247	7	2.3548	7
A4	0.1147	4	5.1702	4	0.8660	4	2.8511	4
A5	0.1109	5	4.9852	5	0.8373	5	2.7514	5
A6	0.0967	6	4.5139	6	0.7301	6	2.4633	6
A7	0.0938	8	4.2577	7	0.7080	8	2.3427	8
A8	0.1324	1	6.0467	1	1.0000	1	3.3217	1
A9	0.1241	3	5.5152	3	0.9375	3	3.0549	3
A10	0.0554	9	2.4810	9	0.4186	9	1.3711	9

alternative A8 stands out as the top-performing service provider. The application of the aggregated multiplication rule allows for the comprehensive evaluation and comparison of the alternatives, ultimately leading to the identification of the most favorable option.

Sensitivity Analysis

This section is dedicated to performing a sensitivity analysis to validate the outcomes of the model. The objective of the sensitivity analysis is to provide decision-makers with the means to evaluate the resilience and dependability of the decision-making process by modifying the parameters of the initial model. In this study, various values of the parameter "λ" within the range of 0 to 1 are employed to perform the sensitivity test.

The performance scores (Ki) of each alternative under different values of "λ" are calculated. By examining the performance scores across these variations, decision-makers can gain insights into how changes in the parameter affect the relative rankings of the alternatives. This sensitivity analysis aids in verifying the stability and consistency of the model, enhancing the confidence in the final decision outcome.

The rankings of each alternative remain unchanged across different values of "λ", as depicted in Fig. 2. This indicates the robustness and stability of the

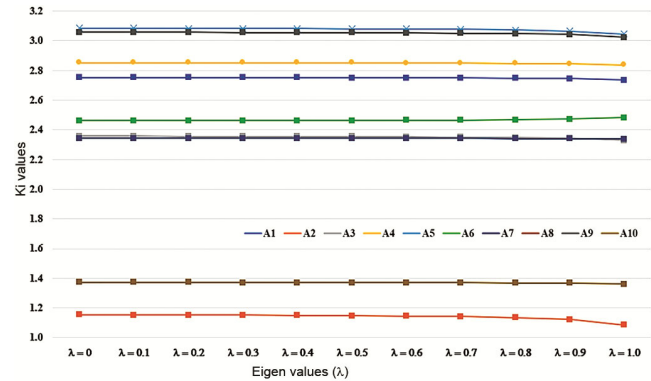


Fig. 2 — Sensitivity analysis

decision-making process, as variations in the parameter "λ" do not significantly impact the relative rankings of the alternatives. The consistency of the rankings across different scenarios enhances the confidence in the validity and reliability of the model, reinforcing the trustworthiness of the final decision outcome. Alternative 8 (A8) is consistently the better solution in all the cases of "λ". Consequently, based on the findings and results obtained, it can be concluded that the performance of the proposed model is deemed satisfactory and reliable. The model demonstrates its effectiveness in providing valuable insights and rankings for decision-making in real-world scenarios. The successful application of the model to this study suggests its potential applicability and relevance to similar real-world cases. This conclusion further strengthens the confidence in the proposed model's viability and encourages its adoption in practical decision-making contexts. The other approaches involving interpretive structural modelling²³⁻²⁶ may also be applied in this case.

Conclusions

This study offers an advanced decision-making framework to tackle the complexities associated with motor insurance policy selection and improve the competitiveness of insurance providers. The proposed joint approach, combining the SF-AHP and the CoCoSo method, provides a robust and efficient means of selecting the most suitable motor insurance policy. Based on the findings, it is evident that the premium amount significantly influences policy selection, while the reputation of the insurance company holds lesser weight among the selected factors. The results obtained from the sensitivity analysis demonstrate the stability and reliability of the model across various Eigen values (λ). This study expands the existing literature and introduces a novel

approach that combines the SF-AHP and CoCoSo methods, which have been scarcely studied in previous research in insurance policy selection domain. The practical implications are significant for both insurers and customers. Insurers can refine policies, increase customer satisfaction, and optimize pricing strategies, enhancing competitiveness. For customers, the framework provides transparency and a data-driven approach for informed decisions, empowering them in the selection process. However, acknowledging limitations such as expert subjectivity is crucial. The future of motor insurance decision-making involves integrating big data, machine learning, behavioral analysis, dynamic pricing, and block chain.

Conflict of Interest

The author has no conflicts of interest to declare.

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