# Prioritizing risk-level factors in comprehensive automobile insurance management: A hybrid multi-criteria decision-making model

# Prioritizing Risk Level Factors in Comprehensive Automobile Insurance Management: A Hybrid Multi-Criteria Decision-Making Modela

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## Abstract

An efficient risk level prediction for newly proposed insurance policies plays a significant role for the survival of companies in the highly competitive insurance market. In Iran, risk assessment in comprehensive automobile insurance, which is a part of motor insurance, is only based on the vehicle attributes without proper consideration of personal and behavioural characteristics of driver(s). As a result, pricing is unfair in most of the cases and this can put insurance companies in an unfavourable financial position due to attracting high-risk drivers instead of low-risk ones. In this scenario, to identify and prioritize important factors affecting risk levels and move towards a fair ratemaking, a two-phase process based on Fuzzy Delphi Method (FDM) and Fuzzy Analytic Hierarchy Process (FAHP) is proposed in this research. Additionally, Similarity Aggregation Method (SAM) is applied to combine the individual fuzzy opinions of the surveyed experts into a group fuzzy consensus opinion. The results of this empirical study contribute to the insurance market of Iran by proposing appropriate weighting of the relevant risk factors to support stakeholders and policy makers for assessing risks more accurately, as well as designing more effective databases and insurance proposal forms.

**Keywords**: Risk, Comprehensive automobile insurance, Fuzzy Delphi Method (FDM), Fuzzy Analytic Hierarchy Process (FAHP), Similarity Aggregation Method (SAM)

# 1. Introduction

Ratemaking strongly affects the profitability of property and casualty insurance, and its factors are fundamental in determining insurance premiums. Due to the competitive nature of insurance companies' strategies, ratemaking must ensure profitability of the insurance business and fair and affordable premiums for consumers, simultaneously. Adequate and reliable historical data is required for the actuaries to fairly determine the rates (Jacqueline Friedland, 2014). In most developed countries, comprehensive databases are already available for actuaries' needs to predict the level of the risk associated with a new insurance proposal. In motor insurance products, homogeneous groups of insureds are made based on their risk level considering a-priori variables and then, a premium according to the losses anticipated to be paid to each group is assigned to the whole group members (Lemaire, 1985).

The focus of this paper is on comprehensive automobile insurance in Iran, which was ranked as the $27^{th}$ and $29^{th}$ country in terms of GDP in the world in 2017 and 2018, respectively. According to the statistics provided by the Central Insurance of Iran (CII), the population of this country was 81.1 million in 2017 and 82.1 million in 2018, and 35.7 and 36.6 million motor vehicles were being used by the people in these years, respectively. Iran generated 10.8 billion dollars of premium in 2018 with an increase of 800 million dollars compared with the previous year and was ranked $39^{th}$ in the world in this regard in 2018 with an improvement from the rank of 42 in 2017. The direct premium in motor insurance, a part of which is comprehensive automobile insurance, was much higher than that of life insurance in 2018 in Iran. Due to the high importance of motor insurance fields in Iran, a special part of the annual report of CII is usually devoted to its statistics and related analysis (*Central Insurance of Iran Statistical Annual Report*, 2019).

As a matter of fact, Iranian insurance industry is suffering from the lack of reliable databases as most of the data required for risk assessment are absent and the fields are not filled out properly by the insurance agencies. Another issue is that ratemaking in motor insurance is mainly based on the specifications of the vehicle, and no attention is paid to the characteristics of the driver(s). Therefore, the available data is not sufficient for proper analysis and risk assessment, which leads to two main challenges: (1) premiums are not fair, and (2) since the policies are issued for each vehicle regardless of the number and characteristics of the drivers, the data gathered in databases are about the vehicle and the policyholder, who is not necessarily the driver.

According to the mentioned problems, it is timely and important to revise the ratemaking system and design new databases. However, if the ratemaking is supposed to be based on the gathered data, changes may be postponed for many years due to the time required for data gathering. A solution to this problem can be utilizing the opinion of experts, who have handled claims for damaged cars and had discussions with the drivers and policyholders, as a valuable source of real-world knowledge.

Therefore, in this research, experts' opinions are applied with the aim to carry out two major benefits: (1) identifying and ranking factors that can contribute in designing a comprehensive database and also efficient proposal forms, and (2) providing numerical values for the weight of the factors which can be beneficial in ratemaking by the actuaries. In this regard, a systematic procedure comprising of Fuzzy Delphi Method (FDM) and Fuzzy Analytic Hierarchy Process (FAHP) is utilized that benefits from Similarity Aggregation Method (SAM), aiming at calculating the weight of major factors in comprehensive insurance risk assessment in Iran.

The remainder of the paper is organized as follows. Section 2 provides a background regarding motor insurance in Iran and factors considered in risk assessment in such policies around the world. It also presents the objectives and theoretical framework of the study. The proposed systematic research model in this study, consisting of FDM and FAHP as well as SAM is reviewed in section 3 and the results of the research are presented and discussed in section 4. Section 5 concludes the research and states the managerial implications of the results. Finally, limitations of the current study and suggestions for further studies are presented in section 6.

## 2. Theoretical background

### 2.1. Motor insurance in Iran

Motor insurance is one of the most important fields of insurance, as a risk transfer mechanism, in Iran, which consists of 3 main parts: (1) automobile third party liability insurance (TPLI), (2) driver's accident insurance, and (3) comprehensive automobile insurance (automobile hull insurance). TPLI compensates third parties for financial damages made to their property, as well as death, bodily injuries, disability and medical expenses caused to them. Besides, driver's accident insurance covers death, bodily injuries and medical expenses imposed on the driver of the insured vehicle. Comprehensive insurance provides coverage for damages made to the insured vehicle mainly caused by fire, car accident, theft, collision and overturning. Theft of vehicle parts, broken glass, compensation for the time the vehicle is out of service, vehicle price fluctuations, natural disasters and damages caused by chemical materials are also some of the allied perils in comprehensive insurance.

TPLI and driver's accident insurance are provided as a single combinatory policy, and according to the provisions of Article one of the Law of Compulsory TPLI in Iran, having this combinatory policy is compulsory for all owners of land transport motor vehicles and their attached trucks and trailers, as well as railway trains. However, insuring the vehicle itself through comprehensive insurance is not mandatory by law. Figure 1 shows the earned premium and the incurred losses in TPLI, driver's accident insurance and comprehensive insurance in comparison with other non-life insurance policies in 2018 (*Central Insurance of Iran Statistical Annual Report*, 2019). As can be seen in figure 1, approximately 40 per cent of the earned premiums and about 59 per cent of the paid losses in the Iranian insurance industry were related to the motor insurance in 2018.

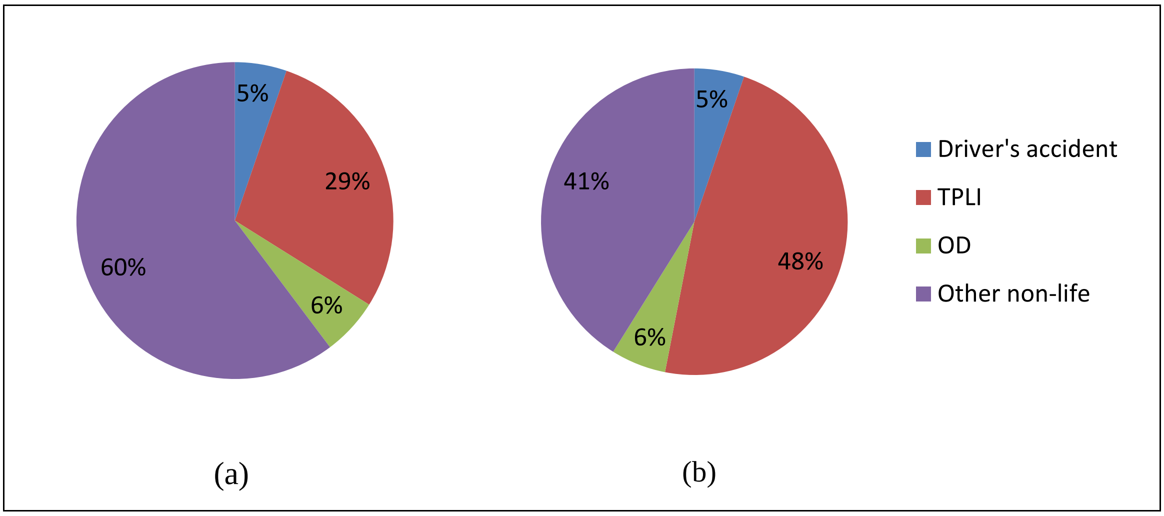


**Figure 1. Earned premium (a) and incurred losses (b) in the Iranian non-life insurance market in 2018**
(*Central Insurance of Iran Statistical Annual Report*, 2019)

In 2018, loss ratio (incurred loss to earned premium) for driver's accident insurance, comprehensive insurance, and TPLI were 67.8 per cent, 67.8 per cent, and 113.9 per cent, respectively, which highlights the importance of the effective ratemaking in this area. Having a loss ratio more than 100 per cent, TPLI has become an unfavourable field in the Iranian insurance industry. However, since it is compulsory for vehicle owners to have this policy, insurance companies inevitably issue it. Comprehensive insurance, as the voluntary part of the motor insurance in Iran, is more favourable for insurance companies as they can decide about the risks picked and the premium rates assigned. Nevertheless, due to the lack of reliable and adequate data, risks are not assessed properly, and many problems have been appeared in the field of ratemaking and premium assignments.

Ratemaking, as the policy premium determination, is a key issue in any insurance field. Premium structure must be fair to all customers and no discrimination should be among the same levels of risk. To set a fair and accurate rate, many factors are considered by different companies in various countries. In 2014, a comprehensive study was conducted by the Insurance Research Centre of Iran (IRC) regarding the risk factors and the calculation of premium in motor insurance in a group of 19 countries including USA, Canada, Denmark, Switzerland, Spain, France, England, Greece, Italy, Ireland, Luxembourg, Norway, Netherlands, Portugal, Sweden, Belgium, Finland, Austria and Germany (Bahador, 2014). In their study, factors affecting the premium amount in the mentioned countries were collected and categorized as drivers' personal characteristics, vehicle characteristics and usage presented in Table 1. The effects of the identified factors on premium calculation are different in each of these countries and a factor such as skin color which is considered effective in a country may be evaluated as an ineffective one in another country. Therefore, due to various economic, legal, social or cultural considerations, there is a need for the variables affecting ratemaking to be customized according to the context of insurance in any country.

**Table 1. Collection of factors affecting ratemaking in motor insurance in a group of countries** (Bahador, 2014)

| Group name | Factors |
|---|---|
| **Drivers' personal characteristics** | |

- Gender
- Age
- Marital status
- Job
- Nationality
- Having a comprehensive car insurance
- Driving accidents and traffic offences
- Additional driving courses
- Membership in driving clubs
- Health status
- Date of driving license
- Month born in
- Loyalty
- Credit
- Education
- Income
- Owning a private house
- Having other insurance policies
- Using public vehicles
- Second career
- Field of education
- Type of driving license
- Skin colour
- Records of fatal or sever injury accidents

**Vehicle characteristics**

- Car type/ model
- Car age
- Car being new or second hand
- Car price
- Car capacity
- Capacity and power of the motor
- Loading capacity
- Maximum speed
- Acceleration
- Type of fuel and its price
- Power to weight ratio
- Weight of the car
- Colour
- Safety equipment(s)
- Structural changes
- Place of steering wheel
- Fuel consumption per 100 km
- Type of financing
- Catalytic converter
- Manufacturing country
- Number of cylinders
- Vehicle symbol

**Vehicle usage**

| | |
|---|---|
| | • Place of residence<br>• Usage of the car<br>• Annual mileage<br>• Number of drivers and their characteristics<br>• Parking place<br>• Geographical region of usage<br>• Using a second car<br>• Workplace region |

## 2.2. Multi-Criteria Decision-Making (MCDM)

Multi-criteria decision making (MCDM) methods are used in decision-making processes based on multiple criteria to provide the best solution among a finite set of parameters to solve a wide variety of problems in different disciplines (Barak & Mokfi, 2019; Štirbanović, Stanujkić, Miljanović, & Milanović, 2019). Various MCDM methods are available in the literature, such as Decision-Making Trial and Evaluation Laboratory (DEMATEL) (Falatoonitoosi, Leman, Sorooshian, & Salimi, 2013; Si, You, Liu, & Zhang, 2018), Simple Multi-Attribute Rating Technique (SMART) (Olson, 1996), Analytic network process (ANP) (Alizadeh, Soltanisehat, Lund, & Zamanisabzi, 2020; Saaty, 2005) Technique for the Order of Prioritization by Similarity to Ideal Solution (TOPSIS), Weighted Product Mode (WPM) and Weighted Sum Model (WSM) (Triantaphyllou, 2000; Zavadskas, Turskis, & Antucheviciene, 2012). These methods have been widely used by scholars in solving problems in different domains such as tourism management (Aksoy & Yetkin Ozbuk, 2017), strategic management (Haddad, Sanders, & Tewkesbury, 2020), computer engineering (Gou, Xu, Liao, & Herrera, 2018), environment (Yang & Wang, 2020), and health care (Thokala et al., 2016).

AHP was primarily introduced by Saaty in 1980 as an MCDM approach and has become one of the most popular methods in this field. It is often used in analysing complex decision processes (Dawid et al., 2017; X. Li & Zhang, 2015; Lidinska & Jablonsky, 2018) and has been extensively applied in various fields of research such as insurance (Ansari, Tabash, Akhtar, Khan, & Al-Matari, 2019; Beiragh et al., 2020), urbanization (Ghavami, Borzooei, & Maleki, 2020; Rajasekhar, Sudarsana Raju, & Siddi Raju, 2019), risk assessment (Wang, Ran, Chen, Yu, & Zhang, 2020), agriculture (Seyedmohammadi, Sarmadian, Jafarzadeh, & McDowell, 2019), sustainable planning (Solangi, Tan, Mirjat, & Ali, 2019), ecological environment (Xu, Xu, & Liu, 2019), food science (Cai et al., 2019), waste management (Ardjmand & Daneshfar, 2020), transportation (Wolnowska & Konicki, 2019) and air transport (Kilic & Ucler, 2019).

However, AHP is often criticized for its incapability in adequately handling the uncertainty and vagueness inherent in the decision-makers’ preferences (Ishizaka & Nguyen, 2013; Kahraman, 2008). In AHP, the measurement for pair-wise comparisons is based on a 1-9 scale. However, in many real cases, evaluations of the decision makers are not realistic to be presented with crisp value due to its vagueness, and they find it more confident to provide internal judgments instead of fixed value judgments. To overcome this shortcoming, Van Laarhoven and Pedrycz (1983) provided FAHP by using Fuzzy set theory to the traditional AHP. FAHP improves the inability of AHP to deal with the imprecision and subjectiveness in pair-wise comparison (Kahraman, 2008), and has been widely used in many domains of research such as risk assessment (Lyu, Shen, Zhou, & Yang, 2020), reusability estimation (Thapar & Sarangal, 2020), e-governance outsourcing (Mahalik, 2014), smart manufacturing (J. Li et al., 2019), manufacturing sustainability (Ocampo, 2019), cloud computing adoption (Sharma, Gupta, & Acharya, 2020) and geochemistry (Behera, Panigrahi, & Pradhan, 2019). Instead of a crisp value, FAHP applies a range of values to incorporate the decision maker’s uncertainty (Yazdi, Nedjati, & Abbassi, 2019), which requires the definition of a membership function for each linguistic judgment.

In Bylaw no. 81 passed by the High Council of Insurance in Iran in 2013, personal characteristics of the policyholder are mentioned as to be important in comprehensive insurance ratemaking and it is recommended to the insurance companies to consider them in their risk assessment. Therefore, the general characteristics of the car and usually the name and contact information of the car owner or policyholder, who is not necessarily the driver, are recorded by the insurance companies. As a result, the main factors that affect the amount of premium for a new policyholder are the attributes and specifications of the car being insured, as well as the type of owner (person/ institution). While issuing a comprehensive insurance policy for a new policyholder that has no records in the insurance system, premium is calculated based on the type of vehicle, number of its cylinders, age of the vehicle and its usage (personal/ taxi/ administrative, etc.). Extent of cover the policyholder asks for, and the terms and conditions of the policy also affect the level of premium.

In the limited research published in Persian language in this regard, as stated by Shams Esfandabadi and Seyyed Esfahani (2018), the available data which were considered as the unique driver’s characteristics were in fact the characteristics of the car owner or policyholder, not necessarily the driver. Furthermore, because of the considerable number of missing values, these studies had to remove a lot of records of the database to find a few reliable records, which surely makes the results biased. The lack of accurate data obviously affects the accuracy of the results, and therefore, they are not reliable for the insurance companies. Furthermore, some of the factors considered in prior researches may not be important for the risk evaluation in Iran; such as the colour of the car. According to the experts' opinions in this research, because of the Iranian culture and the limitations people face for selecting a colour for their car, the vehicle colour is not an important factor in the risk assessment.

Considering the importance of careful reflection of the insurance knowledge while making a decision (WU, KAO, SU, & WU, 2005), our proposed solution for overcoming the challenge of a fair ratemaking in comprehensive insurance is using experts' opinions to determine the effective factors. MCDM approach is applied since the objective of this research is not to compute the optimum solutions, but to provide a ranking of the variables. This research applies FAHP, as a combination AHP and fuzzy logic, which enables the authors to prioritize the target variables in the research and benefit from the fuzzy logic in lowering the imprecision of the experts' opinions.

The steps to use these methods in the current research are presented in section 3 and the results obtained from its application in the Iranian insurance system are discussed in section 4.

## 3. Methodology

This study especially focuses on new customers entering the insurance market, asking for a comprehensive insurance policy for personal light-duty vehicles. Because proper bonus-malus systems can be applied to adjust the premium for policyholders who have previously bought insurance policies, the latter group is not considered.

To identify and weight the factors affecting the risk level of newly proposed comprehensive insurance policies, this study follows a consistent and systematic research structure that is summarized in Figure 2. In the first phase, decision variables, which in this research are the major factors in ratemaking, are extracted from the literature and the knowledge of the experts through utilizing FDM. In the second phase, in order to specify the level of importance and ranking of each factor, FAHP is applied. Trapezoidal fuzzy numbers are constructed based on the individual opinions of the experts and individual fuzzy opinions are aggregated through SAM to obtain consensus. The weight of each impressive factor is the output of the process.

Sub-sections 3.1 to 3.3 provide specific detail about such methodological tools and how they are applied in our study.

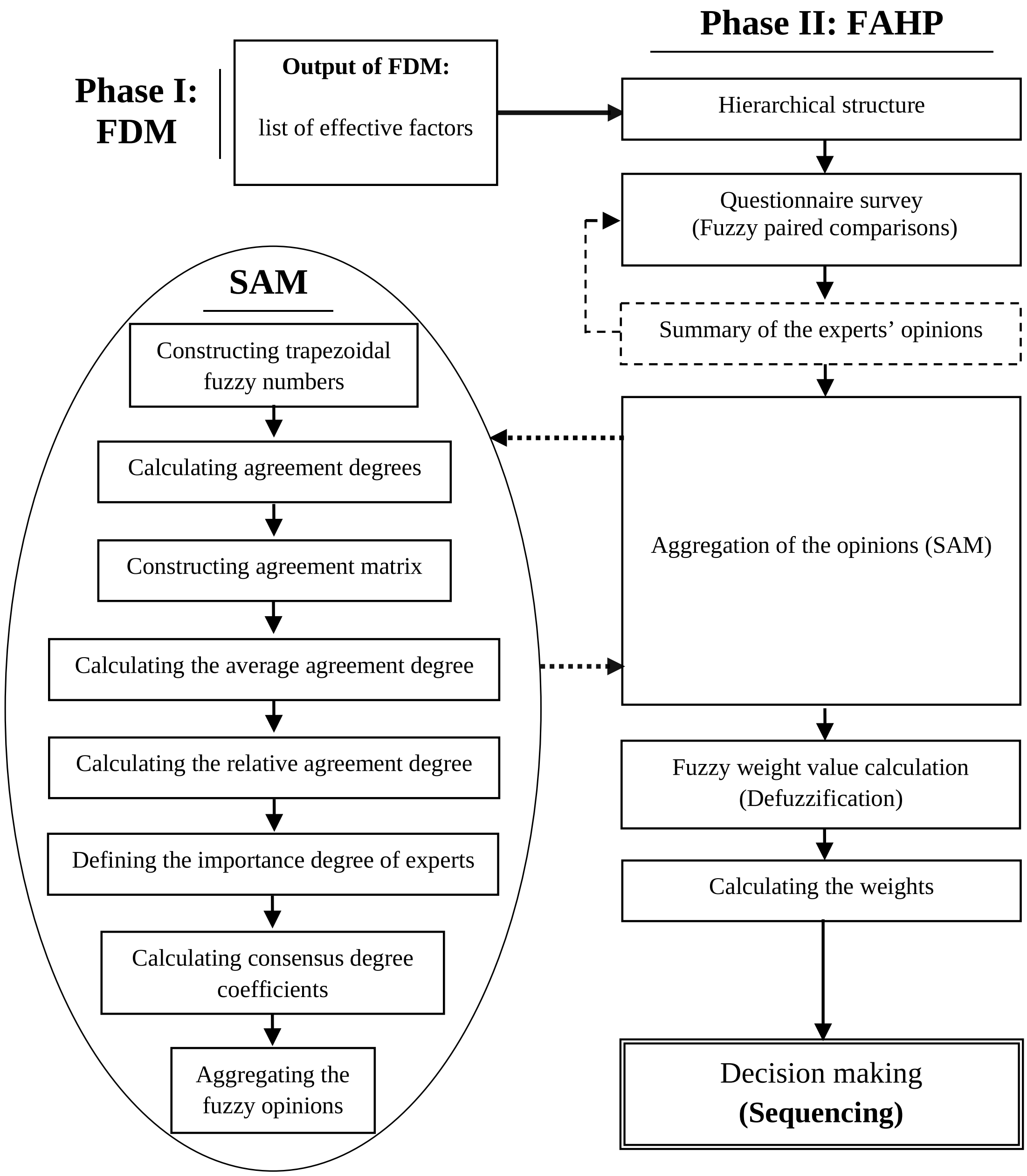


**Figure 2. The research model (Prepared by the authors)**

### 3.1. Fuzzy Delphi method (FDM)

Due to some shortcomings of the Delphi method such as requiring more time and cost for repetitive surveys to obtain convergence in opinions, and linguistic terms being more proper for experts in reflecting their opinions in many real cases, Murray et al. (1985) proposed the combination of fuzzy set theory and Delphi method called Fuzzy Delphi Method (FDM). It is believed that Fuzzy set theory can solve the fuzziness of common understanding of experts engaged with such a decision-making process (Y.-L. Hsu, Lee, & Kreng, 2010). Hence, the present research uses FDM in its first phase.

After reviewing the literature, factors affecting risk level in comprehensive insurance are determined, and the appropriate factors for Iran are selected through interviews with insurance experts and experienced managers. Then, the viewpoints of the decision-makers regarding the importance level of each risk factor in comprehensive insurance are gathered through questionnaires, which are designed in a way that the experts can select a rating interval instead of a specific value. Consistent with the Delphi methodology, a summary of the gathered opinions is the base of the second round of the survey to reach a suitable consensus level. In the next step, the importance degrees provided by the experts are transformed into triangular fuzzy numbers (Klir & Yuan, 1995), and then, defuzzified using the approximation of the three-parameter Beta distribution. Finally, considering a threshold of 0.25, the important risk level factors in comprehensive insurance are listed. The output of this phase, which is reflected in the research published by Shams Esfandabadi & Seyyed Esfahani (2018), is used as the input for the second phase that is FAHP.

## 3.2. Fuzzy Analytic Hierarchy Process (FAHP)

This phase includes the following steps: (1) setting up the hierarchy architecture, (2) collecting the experts' opinions regarding the pair-wise comparison of the factors and setting up fuzzy paired comparison matrices, (3) integrating fuzzy evaluation values (which in this study is done using SAM (H.-M. Hsu & Chen, 1996)), (4) calculating the weight of elements, (5) obtaining the weight of all factors through connecting all parts of the hierarchy, and (6) defuzzifying and providing the sequence of factors based on their importance. After applying SAM for calculating the overall fuzzy numbers of the experts' opinions, a combination of Beta distribution and uniform distribution as stated by Rahmani et al. (2016) is used for defuzzification of the fuzzy numbers, such that the crisp real number $\mu_{\tilde{a}}$ corresponding to each trapezoidal fuzzy number $\tilde{a} = (l, m_1, m_2, u)$ is calculated as:

$$\mu_{\tilde{a}} = \frac{2l + 7m_1 + 7m_2 + 2u}{18}$$

### 3.3. Similarity Aggregation Method (SAM)

SAM was proposed by Hsu and Chen in (1996) as a method for combining the individual subjective estimates. These estimates are presented by trapezoidal fuzzy numbers using most likely and the largest intervals in each pair-wise comparison. If there is no interaction between the initial estimates provided by the experts, Delphi method is applied to adjust the values and obtain a common intersection at a fixed α–level cut. After getting a common intersection between the opinions gathered, agreement degree of the opinions between each pair of participant experts are calculated and an agreement matrix is made. Then, the average agreement degree and relative agreement degree of each expert are calculated. Specifying the importance degree of each expert engaged, Consensus Degree Coefficient (CDC) is calculated for each of them, and finally, fuzzy opinions are aggregated by the CDC.

## 4. Model application, results and discussion

**Phase 1: FDM**

Reviewing the available literature, 62 factors were identified to be influencing the risk level in comprehensive insurance in different countries and areas. Considering the automobile manufacturing industry, insurance industry, law, rules and regulations and also the culture in Iran, 40 factors out of the initial 62 were selected and adopted in our research. For instance, among the omitted factors, we can name “vehicle symbol”, which is not defined in Iran. The selected 40 factors were presented to 9 experts in motor insurance, who were members of Iran Insurers Syndicate and/or senior managers in motor insurance departments in one of the Iranian insurance companies for validation. They added 2 other factors to this selection and deleted 7 factors, leading to the total number of 35 factors.

The final extracted 35 factors were used for designing a questionnaire in which the respondents could express the importance level of each factor in a fuzzy environment. The respondents were 12 experts, some of whom were also interviewed in the previous step. The summary of the obtained opinions was presented to the respondent group, and as required, the questionnaires were filled out by the experts for the second round. Finally, the intervals specified by the experts as the level of importance for each factor were transformed into fuzzy triangular numbers and then, defuzzified. Considering 0.25 as the evaluation criteria for the importance of the factors, 29 factors remained in the list.

To finalize the list and prepare it for the second phase, once more, we interviewed the group of 9 experts we had previously interviewed to check if there were any factors which were important but correlated. The results are as follows: (1) Type of policyholder (person/ institution), type of ownership (legal/ personal/ governmental) and type of car plate (governmental/ personal) are all important but they are highly correlated. Therefore, one of them can be a representative for the three factors. Type of policyholder can be a good choice in this regard. (2) Driver's marital status can be omitted, as it can be reflected by the age of drivers. In fact, Iranian social culture leads people to marry in a certain range of age. Therefore, one of these variables can implicitly indicate the other one. (3) Engine capacity and acceleration can be considered as correlated factors and one of them can be omitted. (4) When a person has more than one car, the annual mileage of each car is less than when they have only one car. Therefore, having another car can be removed from the list of factors and annual mileage is enough to capture the required information. As the price of fossil fuel is low in Iran, most of the people can afford using personal cars instead of public transportation and many families in big cities have multiple cars.

Removing unnecessary factors and grouping the final factors according to the experts' opinion led to the results presented in Table 2. The efficiency of the classification was then checked by using Confirmatory Factor Analysis (CFA) (Shams Esfandabadi & Seyyed Esfahani, 2018).

**Table 2. Finalized list of factors affecting risk in comprehensive automobile insurance and their grouping** (Shams Esfandabadi & Seyyed Esfahani, 2018)

| Group | Factors within group |
|---|---|
| **Personal Characteristics and Ownership** | **A: Non-acquired Characteristics:**<br>• Type of policyholder<br>• Driver(s)'s gender<br>• Driver(s)'s age<br>• Driver's living city<br>• Driver(s)'s health status<br>**B: Acquired characteristics:**<br>• Driver(s)'s occupation<br>• Driver(s)'s education<br>• Type of driving license<br>• Driving experience<br>• Traffic offences (including speed violence)<br>• Claim history in TPLI |

| | |
|---|---|
| | • Multiple drivers for a single car |
| **Car Specifications** | • Acceleration<br>• Number of cylinders<br>• Car age<br>• Safety<br>• Country manufacturing the car<br>• Car price |
| **Car Usage** | • Usage (personal/ taxi/ administrative, etc.)<br>• Parking place<br>• Annual mileage<br>• Geographical driving area |

## Phase 2: FAHP

The final list of the effective variables and their grouping obtained in phase 1 were used for making the hierarchical structure as illustrated in Figure 3. As illustrated in this structure, risk is mainly evaluated by 4 main criteria, namely car specifications, acquired personal characteristics and ownership, non-acquired personal characteristics and car usage. Each of these criteria is evaluated by its own relevant sub-criteria.

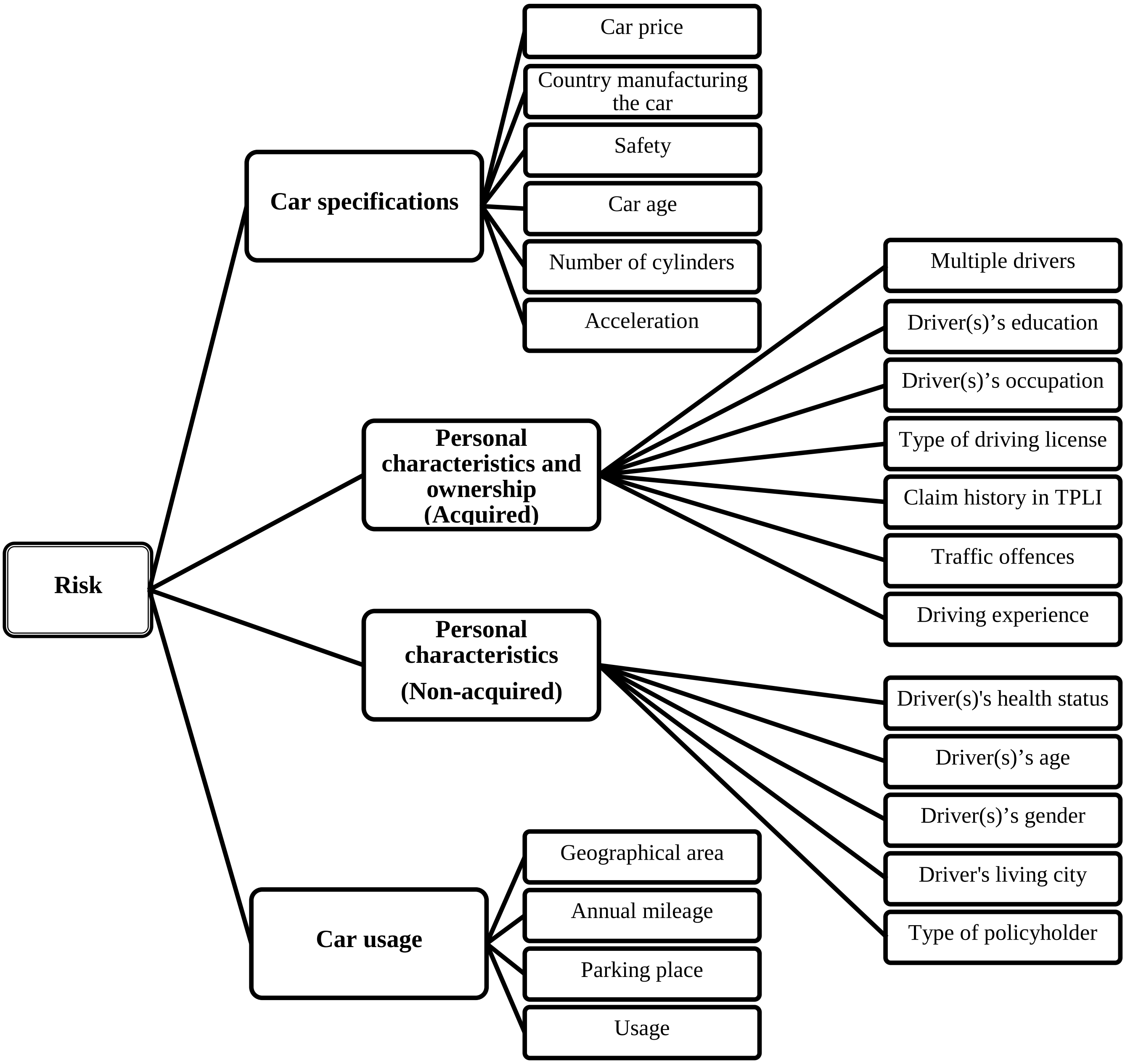


**Figure 3. The hierarchical structure of the evaluation criteria (Prepared by the authors)**

Then, a survey was designed to gather the experts' opinions regarding the pair-wise comparisons of the factors, targeting 6 experts in motor insurance who were members of Iran Insurance Syndicate. In this questionnaire, according to (H.-M. Hsu & Chen, 1996), each of the experts ($E_i(i = 1,2, \dots ,6)$) were asked to specify the most likely and the largest intervals for each pair-wise comparison, i.e. $[b_i, c_i]$ and $[a_i, d_i]$ such that $a_i \leq b_i \leq c_i \leq d_i$. The specified intervals identified a trapezoidal fuzzy number with a common intersection at some $\alpha$ level cut for each of the comparisons and therefore, there was no need to repeat the procedure for filling out the questionnaire.

At this step, since all the 6 experts had rather similar experience, equal weights were considered for all the experts and SAM was applied to aggregate the opinions gathered. The calculated overall fuzzy numbers of combining experts' opinions were converted into crisp values by using the method explained by Rahmani et al. (2016) and were used for calculating the weights in the AHP structure. The weights calculated for each criterion, the Consistency Index (CI) for each comparison matrix, the Consistency Ratio (CR) for the comparison matrices, as well as the global priority of each criterion and its rank is provided in Table 3. The calculated CR for level I (main criteria in the AHP structure) and the whole AHP structure is approximately 0.020 and 0.062, respectively, which indicate acceptable ratios ($< 0.1$).

**Table 3. Weights, CI, CR, global priority and ranking of the criteria (Authors' calculations)**

| Criterion | CI | CR | Weight within Comparison Matrix | Global Priority | Ranking |
|---|---|---|---|---|---|
| **Personal Characteristics (Non-acquired)** | 0.033 | 0.029 | 0.153 | | |
| Type of policyholder | | | 0.130 | 0.0199 | 21 |
| Driver(s)'s gender | | | 0.181 | 0.0277 | 19 |
| Driver(s)'s age | | | 0.286 | 0.0436 | 14 |
| Driver's living city | | | 0.090 | 0.0137 | 22 |
| Driver(s)'s health status | | | 0.313 | 0.0477 | 11 |
| **Personal Characteristics and Ownership (Acquired)** | 0.130 | 0.099 | 0.381 | | |
| Driver's occupation | | | 0.112 | 0.0425 | 15 |
| Driver's education | | | 0.128 | 0.0486 | 9 |
| Type of driving license | | | 0.091 | 0.0346 | 17 |
| Driving experience | | | 0.164 | 0.0625 | 3 |
| Traffic offences (including speed violence) | | | 0.210 | 0.0801 | 1 |
| Claim history in TPLI | | | 0.187 | 0.0713 | 2 |
| Multiple drivers for a single car | | | 0.110 | 0.0418 | 16 |
| **Car Specifications** | 0.004 | 0.003 | 0.256 | | |
| Acceleration | | | 0.133 | 0.0340 | 18 |
| Number of cylinders | | | 0.106 | 0.0272 | 20 |
| Car age | | | 0.188 | 0.0482 | 10 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Safety | | | | 0.185 | 0.0473 | 12 |
| Country manufacturing the car | | | | 0.180 | 0.0460 | 13 |
| Car price | | | | 0.207 | 0.0531 | 6 |
| **Car Usage** | 0.001 | 0.001 | 0.210 | | | |
| Usage (personal/ taxi/ administrative, etc.) | | | | 0.258 | 0.0542 | 5 |
| Parking place | | | | 0.260 | 0.0545 | 4 |
| Annual mileage | | | | 0.249 | 0.0524 | 7 |
| Geographical driving area | | | | 0.233 | 0.0489 | 8 |

According to the calculated ‘weight within Comparison Matrix’, the characteristics and experiences a person can obtain over time have the highest weight among the three other groups of factors. This is not reflected in the Iranian system of comprehensive insurance ratemaking. However, the bonus-malus system that is applied when renewing a policy tries to reward low-risk drivers by assigning various discount rates.

Referring to the ‘global priority’ and the associated ‘ranking’, the top position refers to traffic offences (including speed violence) that is put under the heading of ‘acquired personal characteristics’. Traffic offences in Iran are mainly recorded for the car, not the driver, unless the car is stopped by the police for specific offences and negative driving marks are given to the driver. Besides, as stated before, the motor insurance policies are issued for each car in Iran, and different people can drive the same car without buying a new policy. Therefore, when a new insurance policy is going to be issued, accounting for the traffic offences recorded for a car might be a proxy of the risk level of the people driving that car. ‘Claims history’ in the compulsory TPLI policy, which is ranked second, can provide other useful pieces of information regarding the behaviour of the drivers. This factor is followed by ‘driving experience’ as the third important factor that focuses on other personal aspects of the drivers.

Since comprehensive insurance policies concentrate on the damages caused to the car itself, it becomes important where the car is parked, for which purposes it is used, how much it is worth, and how many miles per year in which areas it is driven. If the car is parked outside a parking area or garage, or in case it is used as a taxi or for ridesharing purposes, it is prone to more damage (M Ranjbari, Shams Esfandabadi, & Scagnelli, 2019). Besides, the more expensive the car, the higher the possible claim. This explains why parking place, usage of the car, car price, annual mileage and geographical driving area are placed at the fourth to eighth ranks.

Another important result is the least significance of ‘non-acquired personal characteristics’. Although there is commonly a misconception among Iranians that age and gender of the driver are two considerable influential factors and women are riskier than men in terms of driving, the results do not reflect it. According to the results, age and gender of the drivers are not among the first half of the ranked important factors regarding comprehensive insurance. In fact, the drivers’ behaviour has a higher significance than age and gender.

Notably, the ‘geographical driving area’ (ranked 8) and ‘driver’s living city’ (ranked 22) indicate different useful pieces of information. In many parts of Iran, people work in a city that is far from their hometown. This happens more often in cities within Tehran Province (embracing the capital city) and its neighbouring provinces, especially Alborz Province. Besides, the growing activities of ridesharing and ride-hailing companies in big cities have led many drivers to join this up-trending sector (M Ranjbari et al., 2019; Meisam Ranjbari, Morales-Alonso, Shams Esfandabadi, & Carrasco-Gallego, 2019). Therefore, the geographical area they work-in earns more importance than the city in which they drive and park their car.

The obtained results are much different with the available studies published in Persian (as mentioned by Shams Esfandabadi & Seyyed Esfahani (2018)), which mainly have applied data-mining techniques and used the available inefficient databases. Especially, the variables related to the behaviour of the drivers, which are ranked 1 to 3 in this research, are not captured in the previous studies about the Iranian comprehensive automobile insurance. Nevertheless, it is highly recommended to the insurance companies to use the results of this study to efficiently revise their proposal forms, enrich their databases and improve their ratemaking. Not only insurance companies and their stakeholders would benefit from such changes, but also there would be a significant improvement in the future scientific research in this area.

## 5. Conclusions and managerial implications

An effective fair and accurate ratemaking strategy brings a long-run competitive advantage for companies involved in the insurance industry. To formulate this strategy, identifying and evaluating risk factors for defining an efficient risk level prediction regarding the new insurance policies are essentially required.

Comprehensive automobile insurance policies in Iran are issued only considering vehicle attributes and without gathering relevant data regarding personal and behavioural characteristics of the driver(s), which results in the lack of a reliable database to be used by the actuaries for determining the risk level and ratemaking. Therefore, alternative methods should be applied to help insurance companies identify and assess the risk level of their insurance policies more technically in details.

Although many factors have been introduced in different countries as the factors affecting the risk level in automobile insurance policies, not all these factors are applicable for Iran due to its economic, social and cultural specifications and there is a need for these variables to be customized. This study identifies and ranks the effective factors to account for in assessing the risk level in comprehensive automobile insurance based on the evidence involving experts' opinion. In this regard, a two-phase procedure is proposed, in the first phase of which, FDM is utilized to obtain the important factors that must be considered in the risk level prediction. The second phase applies FAHP to find the importance degree of each factor in ratemaking, while SAM is utilized to combine individual fuzzy opinions of the experts into a group fuzzy consensus opinion.

Although car specifications are very important in the Iranian motor insurance policies and the policies are issued for the cars rather than the drivers, the weights calculated for the factors in this research highlight the importance of personal characteristics and experiences that the drivers acquire over time. These characteristics include traffic offences (including speed violence), claim history in TPLI and driver's driving experience, which are the top 3 ranked risk factors in this research. Therefore, it is very crucial and timely for insurance companies to start considering the identified factors to reach a more precise risk assessment. In Iran, the importance of considering the drivers' characteristics together with the car specifications when issuing comprehensive automobile insurance policies must be considered by the CII and other legislative bodies, too.

The results of this empirical study contribute practically to the insurance business market of Iran and also some developing and less developed countries. It helps stakeholders and policy makers assess the potential risks more accurately to design a fair ratemaking system and more effective insurance proposal forms. It is also helpful for the CII, as the legislative authority in the insurance industry, to draft more operative instructions and design an effective database for gathering the required data regarding the insurance policies. If the risk factors are properly assessed, the claims level of the comprehensive insurance policies can be more realistically predicted, which leads to attracting good risks and making the bad risks improve or leave the company.

Although this study provides the framework for future studies to analyse risk in the comprehensive automobile insurance and its ratemaking, it comes with some limitations that can be addressed in the future research. First, this research investigated only light-duty vehicles and ignored the heavy vehicles and trucks due to their special applications and differences. Therefore, more research is required on the other types of vehicles. Second, the focus of this research was on the comprehensive insurance in Iran. However, the applied methodology deserves to be utilized for the other lines of business in the Iranian insurance industry or any other developing or less developed country lacking an efficient list of ratemaking factors. A good concentration for further research can be the TPLI in Iran, whose loss ratio has reached approximately 113.9 per cent in 2018–2019, and this is a serious alarm for the insurance industry. Since TPLI is mainly focused on the injuries and damages caused to the third parties, the role of the drivers and their characteristics are very significant in this type of insurance. This is while the TPLI is issued for each vehicle in Iran and no attention is paid to the person(s) driving the car. Therefore, a serious investigation on the ratemaking and the risk factors in this type of insurance is highly recommended to be considered in future research. A further step to enrich future studies applying the suggested methodology can be using the obtained results for designing efficient decision support systems (DSS) to improve decision-making in specific insurance business areas. This suggestion can also be applied to the present study. Finally, the current unexpected COVID-19 pandemic crisis has made some challenges in terms of transportation for the people around the world, which can affect automobile insurance line of business as well. Changes in the behaviour of the people regarding the usage of various transport modes affect the risk level of the automobile insurance policies, which should be further investigated by the insurance companies to make fair and adequate insurance rates. Moreover, proper prediction of the people’s behaviour to use their personal cars after the pandemic can improve the risk assessment and insurance product design, which deserve more attention in future research.

## Acknowledgement

This Study has been conducted with the cooperation and support of the Insurance Research Centre affiliated to the Central Insurance of Iran. We would also like to express our deepest gratitude to the members of the Iranian Insurers Syndicate for their supports and time spent in doing this research. However, this research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Besides, the authors are grateful to the anonymous referees of the journal for their extremely useful suggestions to improve the quality of the paper. Usual disclaimers apply.

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