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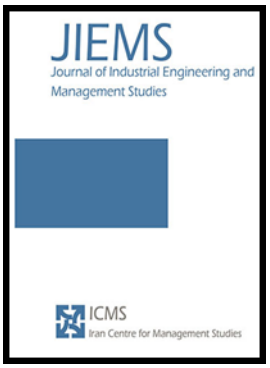

Identifying and classifying the factors affecting risk in automobile hull insurance in Iran using fuzzy Delphi method and factor analysis

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Abstract

Automobile hull insurance has attracted much attention due to the high rate of vehicle applications in daily lives. Since purchasing these policies is optional in Iran and their premium rates are set competitively, a competition is formed among the insurance companies for attracting low risk drivers. However, most of the insurers still use comparative rates and pay no or less attention to the factors affecting risk in premium calculations. Considering the importance of fair ratemaking in attracting and maintaining good risks and encouraging bad risks to repent or leave the portfolio, and taking into account the shortcomings of the available databases, this paper focuses on determining and classifying the risk factors affecting premium calculation in automobile hull insurance from the viewpoint of the experts. In this regard, Fuzzy Delphi method is utilized, the factors are classified and the efficiency of the classification is checked by using Confirmatory Factor Analysis (CFA).

Keywords: Automobile hull insurance, Risk, Fuzzy Delphi method, Confirmatory Factor Analysis (CFA), Partial Least Squares (PLS).

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1. Introduction

Automobile insurance is an important line of business which comprises a huge share of the insurance industry portfolio. Based on the most recent information from the statistical yearbook of the insurance industry 1395 (2016) that was published in 2017, more than 54.28% and 55.58% of the total premium in nonlife insurance policies issued in the years 1394 (2015) and 1395 (2016), respectively, were gathered from automobile insurance policies; and the share of hull insurance from the premium in automobile insurances in these two years were 12.48% and 10.92%, respectively.

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Besides the premium, the loss ratio attracts attention in this field. Loss ratios of 61.8% and 69.6% for the years 1394 (2015) and 1395 (2016) in automobile hull insurance (Statistical yearbook of the insurance industry 1395 (2016), 2017) highlights the importance of fair ratemaking based on the proposed risk to the insurance companies by the proposers. Fair premium rates lead to risk control and reducing the abnormal behaviors of the high-risk drivers. Therefore, they play a vital role in reducing the loss ratio in automobile insurance. As setting the tariffs in hull insurance is competitively done by the insurance companies, and buying this type of policy is optional for the drivers, calculating fair premium rates in this line of business would help the insurance companies to attract good risks and push away bad risks. In the current ratemaking system in governmental and private insurance companies in Iran, not a big difference is being considered between high risk and low risk drivers, as human factors and personal characteristics of the drivers are not being taken into account in the ratemaking. In fact, the factors that are considered in the hull insurance ratemaking are only based on the automobile and its specifications.

In this type of insurance, after the abolition of using the compulsory rates by the High Council of Insurance in 2009, most of the insurers are used to set the rates based on what other competitors announce (Insurance Research Center 2014). In the bylaw No. 81 of the High Council of Insurance, which was passed in March 1991, insurance companies were obliged to determine the premiums of a vehicle, not only based on factors related to vehicle specifications and the type and scope of its use, but also considering the number of its drivers and the policyholder's characteristics including age, education, gender, occupation, etc. (High Council of Insurance 2012). But what is happening right now is that premiums for personal automobiles are set according to the type of vehicle and the number of cylinders, the production year and use of the vehicle, taking into account the risks covered and the period of the insurance coverage. Of course, some insurance companies also consider the number of drivers and consider a discounts on premium for the automobiles that have only one driver.

Considering extensive research and studies on the factors influencing the determination of the premium rates for the automobile hull insurance, as well as by applying the relevant regulations and reviewing proposed offers from insurance companies and by polling experts and specialists in this area, The Insurance Research Center, Affiliated to the Central Insurance of Iran, has calculated some proposing rates and has published it in "Advisory Rates" (Insurance Research Center 2014). In calculating these rates, the type of vehicle (passenger cars, auto car, truck, motorcycle or other vehicles), vehicle capacity (based on the maximum weight or the number of passengers to be carried), engine capacity, cylinder number, type of plate (organizational, personal, general, etc.), manufacturing year, vehicle safety features (ABS, EBD, etc.), claims history, vehicle weight and type of use (service, road construction, agriculture, etc.) have been introduced as factors and criteria influencing the premium rates. It is obvious that despite the precision in determining the factors and the calculation of rates, neglecting the factors associated with the individual characteristics of the driver makes the risk of the applicant's insurance not to be evaluated well and therefore, he will not be put in the right position in terms of the level of risk (Baecke and Bocca 2017).

In addition, the available data regarding the personal characteristics of the drivers are non-reliable; because the policy holder's information in captured by the insurance companies, while this person is not necessarily the driver. In addition, more than one driver may use a single car. Therefore, there is a need for creating a comprehensive and coherent database, which captures the necessary information for the insurance companies to calculate fair rates and helps making suitable systems of policy issuance in the insurance industry.

On the other hand, when the customers face too many questions in the proposal form, they may leave some of the questions unanswered, or if it is compulsory to reply all the questions, they may not give accurate answers.

Therefore, it is important to shorten the questions in the proposal forms and ask only for the pieces of information which are essential. Many other pieces of information such as the mileage driven or traffic offences can be captured via other instruments and platforms.
In this paper, considering such problem and limitations, factors affecting risk in the automobile hull insurance are identified by utilizing Fuzzy Delphi Method, and then, they are classified and the highly correlated ones are omitted. Confirmatory Factor Analysis (CFA), which is a part of Structural Equation Modeling (SEM), is used for the confirmation of the model. The final classified factors can provide a better sense regarding the risk evaluation and fair premium calculation in automobile hull insurance, and can build up a comprehensive but not too long proposal form.
The remainder of the paper is organized as follows. Section 0 reviews the research background, focusing more on the Iranian research papers on automobile hull insurance. Methodology applied in this research is stated in section 0, followed by the discussion on the obtained results in section 0. Finally, section 0 concludes the paper and paves the way for future research.

2. Research background

Many researches have been conducted regarding the factors affecting risk in automobile insurances (Baecke and Bocca 2017, Lahrmann et al. 2012, Paefgen, Staake and Thiesse 2013, Aseervatham, Lex and Spindler 2016) and insurance companies are trying to use the latest technologies to capture the required data for assessing the risk more accurately (Jukić et al. 2015).
Iranian insurance companies gather and keep much data about their customers. However, as this data gathering is not organized and targeted, they cannot be used well for purposes such as the determination of risk levels. For example, Hanafizadeh and Rastkhiz-Paydar (2011) and Hanafizadeh and Rastkhiz-Paydar (2013) determined 24 factors in 4 groups of demographic, vehicle specifications, driver's record and the policy attributes as the effective factors on the risk level of automobile hull insurance customers. However, considering the inadequacy of the available information in the database of the case company, 5 factors out of the 24 introduced were omitted at the beginning stages of the research process. The omitted factors were age, type of driving license, driver's driving experience, engine capacity and driving speed. Since these factors were realized as to be effective by the experts, omitting these factors surely can affect the research results. Other Iranian research papers, which are done by applying data mining techniques also have the same problem and have done their analysis based on the available data. It is worth mentioning that this does not show the weakness of the researches conducted, however, their application in the real world have limitations. As examples of other papers that have done a risk classification and loss determination in the Iranian hull insurance policies, Haji-Heidari et al. (2011), Izadparast et al. (2012), Anbari, Nad-e-Ali and Eslami Nosratabadi (2010), and Dehpanah and Torkestani (2014) can be named. All these papers have applied different tools and techniques of data mining.
Hanafizadeh and Rastkhiz-Paydar (2011) clustered hull insurance customers using Self-organizing maps (SOM) and then, extracted the characteristics of the customers in each cluster to be used in ratemaking. These scholars in 2013 compared the risk classification of customers using SOM and k-means algorithm. Haji-Heidari et al. (2011) and Anbari, Nad-e-Ali and Eslami Nosratabadi (2010) used decision-tree, Neural Networks, Bayesian Network, Support Vector Machine (SVM), logistic regression and differentiation analysis to cluster and classify the risk of automobile hull insurance customers and compared the results of these algorithms. Izadparast et al. (2012) used decision-tree and k-means algorithm to predict the level of risk for the hull insurance customers and Dehpanah and Torkestani (2014) used Neural Networks to anticipate the potential loss of policyholders in this type of insurance.

Any of the mentioned researches have used the variables according to the available data, and some of them have even limited the range of variables regarding type of the vehicle or its manufacturing year because of deficiencies in data. Some factors regarding the characteristics of the policyholders are also considered, which need more attention. The problem is that policyholders' information is saved in the insurance companies' database; however, this person is not necessarily the driver of the insured car. Therefore, referring to these characteristics can make some problems in the risk assessment for the policies.

Another problem that the researches face when using the available database of the Iranian insurance companies is that when looking for records with no or less missing value and with correct data, very low number of records are remained. Hence, a significant reduction in the amount of available data happens, which lead to significant biases in the results. If data collection systems in the insurance companies are improved and the required information for useful and efficient analysis in the insurance industry is provided, data mining can be very successfully applied in this field. Among the articles that have been written in and this regard, we can refer to Yeo et al. (2001) and Yeo et al. (2003) as examples.

Taking into account the variety of factors considered for risk assessment in other countries (Insurance Research Center 2014a, Insurance Research Center 2014b) and having in mind the current limitations in Iran, which was mentioned in this section and also the introduction, the importance of building stronger and more general databases in the insurance companies is highlighted. This would help actuaries to make better estimations and calculations. However, it takes a long time to prepare a reliable database, on which the managers can decide which factors to consider as the effective ones and to what extent. Therefore, by the time such database is designed and adequate information for decision making is gathered, using the opinions of the experts can lead us towards determining the effective factors on risk in such insurance policies and can help insurance companies to revise their proposal forms to gather the required data from the customers. Therefore, this paper tries to determine the effective factors on the risk level for passenger cars in the automobile hull insurance policies by using Fuzzy Delphi method, and then, classifies them by applying Confirmatory Factor Analysis (CFA). This will help insurance companies to reduce the number of their questions in the proposal forms, while keeping the acceptable quality for gathering all the information required.

3. Methodology

The data in this research is gathered through library searches and also questionnaires and interviews. The designed questionnaires for capturing the list of effective factors through Fuzzy Delphi method are filled out by a group of automobile insurance department managers and their deputies, technical managers of the insurance companies and some members of Iran insurers syndicate in automobile insurance workgroup, and the interviews for initial classification of factors are also done with the same group. The second questionnaire for doing the CFA are filled out by a number of insurance experts in automobile insurance departments in various Iranian private and governmental insurance companies.

Four steps are taken to do this research, which are shown in Figure 1.

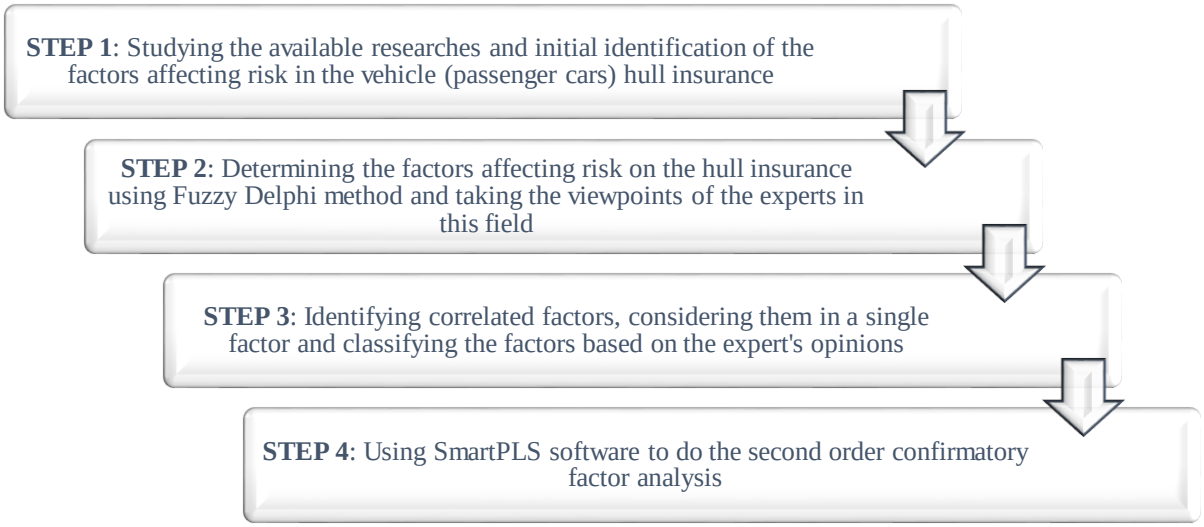

Figure 1. The methodology framework

STEP 1: Initial identification of the factors affecting risk in the passenger cars hull insurance

The Insurance Research Center in Iran has done a research project, parts of the result of which is published in Insurance Research Center (2014a) and Insurance Research Center (2014b). According to the results obtained in this research project, 24 factors regarding personal characteristics of the driver, 22 factors regarding vehicle characteristics and 8 factors regarding vehicle usage are considered in 19 different countries[2] for determining the risk in automobile insurance policies, generally (Third Party Liability (TPL) insurance and hull insurance). Reviewing other available related scientific and experimental sources and considering the factors mentioned by the Insurance Research Center, a list of effective factors are extracted, out of which, those factors that are logically applicable for Iran are selected. These factors are used in designing a questionnaire for gathering the experts' opinions regarding the level of effect of each variable.

STEP 2: Determining the factors affecting risk using Fuzzy Delphi method

Fuzzy technique, which was introduced by Rand in 1950s, has been widely used in various situations as a method to take the expert's common opinions. It is one of the ways to access the group knowledge and consists of a structured process foresee and help the decision making process through several replications of information gathering that finally reaches a group consensus (Imani Jajarmi 2000, Ahmadi, Nasiriani and Abazari 2008, Linstone and Turoff 2002, Okoli and Pawlowski 2004). As reaching this consensus may take much time, energy and cost, and there is a probability that the opinion of some experts are deleted, Fuzzy Delphi method (FDM), which is a combination of fuzzy set theory (Zadeh 1965) and Delphi method, was proposed by Murray et al. in 1985 to overcome the fuzziness existing in the common understanding of the experts regarding the solution of a common problem.

In this step, Fuzzy Delphi method is applied to take the viewpoint of experts regarding the factors affecting risk in the considered insurance.

The stages to apply fuzzy Delphi method in this step are as follows.

[2] The countries considered in this project included USA, Canada, Denmark, Switzerland, Spain, France, England, Greece, Italy, Ireland, Luxembourg, Norway, Netherlands, Portugal, Sweden, Belgium, Finland, Austria and Germany.

1. Gathering the viewpoints of the decision makers group: At this stage, the viewpoints of the experts regarding the importance of each factor is gathered through the designed questionnaires. These questionnaires are designed such that the viewpoint of the experts are reflected through selecting an interval instead of a specific number for each of the questions. Experts can also add new factors to the list provided.

2. Creating triangular fuzzy numbers: The degrees of importance captured in the first stage are transformed into triangular fuzzy numbers. To do so, the method in Klir and Yuan (1995) is used. In this method, the importance degree of factor j, which is determined by the i^{th} expert among n experts, is set as $\widetilde{w_{ij}} = (a_{ij}, b_{ij}, c_{ij})$, where $i = 1,2, \dots, n$ and $j = 1,2, \dots, m$. Note that b and c are the vertices of the fuzzy triangular number. Then, the fuzzy weight of the jth factor is calculated as $\widetilde{w_j} = (a_j, b_j, c_j)$, such that:

$$a_j = \text{Min}_i\{a_{ij}\} \qquad b_j = \frac{1}{n}\sum_{i=1}^{n} b_{ij} \qquad c_j = \text{Max}_i\{c_{ij}\}$$

3. Defuzzifying: In order to defuzzy the fuzzy weight $\widetilde{w_j}$ of each factor and transform it into the crisp amount of S_j, the approximation of the three-parameter beta distribution with the following formula is used.

$$S_j = \frac{a_j + 4b_j + c_j}{6} \qquad j = 1,2, \dots, m$$

4. Screening by evaluation criteria and providing the results: At this stage, considering the threshold α, and taking into account the following 2 rules, the effective factors and almost non-effective factors are segregated.

- If $S_j \geq \alpha$, then the jth factor is considered as an effective one, and
- If $S_j < \alpha$, then the jth factor is omitted.

No special rule is available for setting the value of α. However, the amount considered for this value directly affects the number of variables to be omitted. In this research, considering the high number of proposed variables in one hand, and their importance on the other hand, $\alpha = 0.25$ is considered as the threshold. The schema of this threshold is illustrated in figure 2.

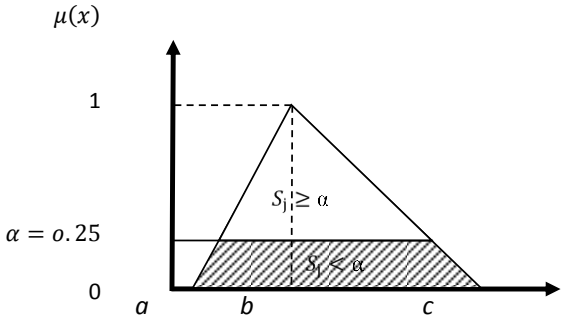

Figure 2. The schema of threshold α

STEP 3: Identifying correlated factors and doing the classification based on experts' opinions
In this step, the list of factors extracted from step 1 is presented and discussed in an interview with the experts. The factors which are correlated or can be determined by other clear factors in the list are identified by the experts and merged with relevant factor. Finally, the remaining factors are classified in suggesting groups based on their origin. This classification is used for building a model for doing the CFA to check the relationships.

STEP 4: Using SmartPLS software to do the confirmatory factor analysis
In this step, a model is built in SmartPLS software to do the CFA by using Partial Least Squares (PLS) method. This method is used to reduce the number of factors, as it is a method for dimension reduction based on correlation between the variables and is used when a number of independent variables have a correlation (Maitra and Yan 2008, Barker and Rayens 2003, Nguyen and Rocke 2002, Nguyen and Rocke 2004, Mehmood et al. 2012). While Principle Component Analysis (PCA) is considered as an unsupervised dimension reduction methodology, this method is a supervised dimension reduction methodology (Maitra and Yan 2008). Liu and Rayens (2007) believe that when dimension reduction is required, PLS is surely preferred to PCA (Liu and Rayens 2007). PLS can be used for both continuous and ordinal data (Maitra and Yan 2008) and therefore, is suitable for our research. To apply this method, SmartPLS software is utilized for doing a Confirmatory Factor Analysis to make sure about the determined correlations between the factors.

4. Results and Discussion

More than 60 factors affecting risk in automobile insurance were extracted from the related scientific and experimental sources, out of which, 40 factors that were logically applicable for Iran were selected. Later on, 2 other factors were added by the experts; and the number of factors reached 42. Of these factors, 35 were recognized by a group of 9 experts as to be the effective ones. The experts' opinions regarding the effectiveness of each factor that were gathered through questionnaires were transformed into triangular fuzzy numbers and then, were defuzzified. Considering $\alpha = 0.25$, six factors were deleted from the list and the remaining effective factors were analyzed in interviews by the experts to identify the correlated ones. This would ease data gathering in proposal forms at the beginning of policy issuance process. After reducing the number of factors, based on the experts' opinion, 3 groups of factors were created, which affect the risk in the policies being studied. These groups and their underlying factors are listed in Table 1. Factors that were correlated according to the interview results are put in the same cell.

Table 1. Identified factors and their grouping

Group title	Factors in the groups
Personal characteristics and ownership	• Type of policyholder (real person/legal person) • Type of ownership (legal/ personal/ governmental) • Type of car plate (governmental/ personal)
	Driver(s)'s gender
	• Driver(s)'s age • Driver's marital status
	Driver's residence city
	Driver's occupation
	Driver's education
	Type of driving license
	Driving experience
	Traffic offences (including speed violence)
	Claim history in TPL
	Physical condition of the driver
	Multiple drivers
Car specifications	• Engine capacity • Acceleration
	Number of cylinders
	Age of the car
	Safety (such as ABS and EBD)
	Country manufacturing the car
	Car value
Car usage	Usage (personal/ taxi/ administrative, …)
	Parking place
	• Annual mileage • Having another car(s)
	Geographical are the car is driven in

It is important to emphasize that in the "Personal characteristics and ownership" group, the characteristics of the main driver(s) is considered not the policyholder, because policyholder is not necessarily the driver.

This is also worthwhile mentioning that "number of claims in the previous year" and "claim-free years" may be effective in the premium calculated by the insurance companies based on the Bonus-Malus system (BMS); however, these factors can be applied for the policyholders who want to renew their policies. Since in this paper, the focus is on the new policyholders and their risks, these two factors are not applicable.

Besides, premium is a function of other factors. Therefore, it is not out in the proposal form. However, when calculating the premium rate and the discount rates, the insurance companies must consider that when people pay more premium, they are more interested to report a claim.

After putting the factors in groups, the second questionnaire was designed based on the results obtained from experts' opinions and was distributed among a group of experienced workers in the field of hull insurance in different Iranian insurance companies and the received questionnaires were analyzed. The Skewness and Kurtosis of the data were in an acceptable range (Byrne 1994) with Skewness between -1.98 and 0.28 and Kurtosis between -1.32 and 5.53. Therefore, distribution was considered as a normal one.

An initial model was constructed based on the results in Table 1 and tested by partial least squares using SmartPLS (version 3) software. Figure 3 and Figure 4 illustrate the model with standard solution and T-value, respectively.

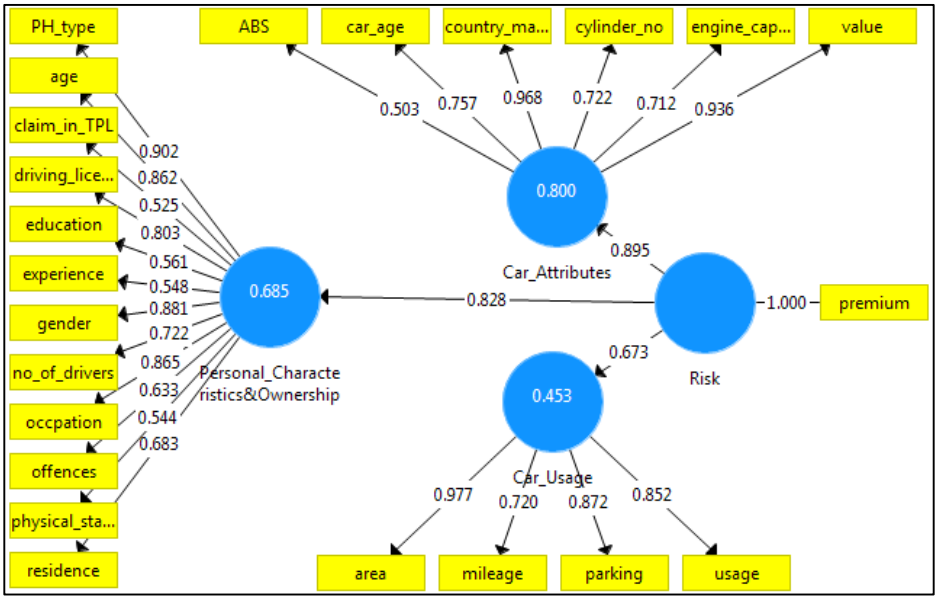

Figure 3. The constructed model with standard solution

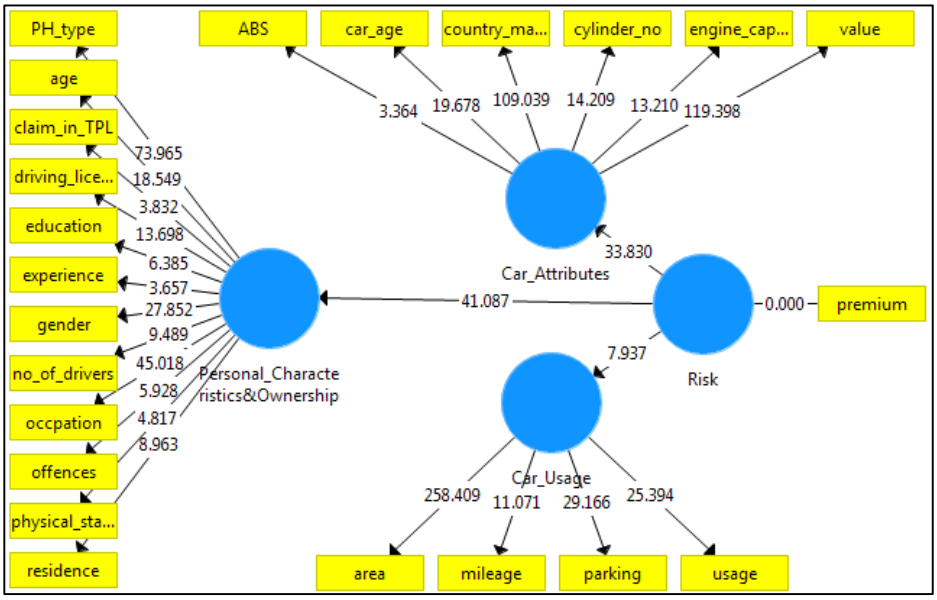

Figure 4. The constructed model with the T-values

The path coefficients shown in Figure 3 indicate the strength of relationship between the two variables. According to (Fornell and Lacker 1981) these coefficients must be more than 0.5, or ideally 0.7. Therefore, this condition is satisfied in this model.

Moreover, as shown in Figure 4, the T-value calculated for all the paths are higher than the standard amount (-1.96 to +1.96 for α=0.05). Therefore, we can conclude that the factors considered can impact the risk in hull insurance, which can be reflected by its premium.

To check the construct reliability and validity, quality criteria as in Table 2 is calculated.

Table 2. Construct reliability and validity of the model

	Cronbach's Alpha	rho_A	Composite Reliability	Average Variance Extracted (AVE)
Car specifications	0.863	0.913	0.901	0.611
Car usage	0.878	0.904	0.918	0.739
Personal Characteristics and ownership	0.878	0.963	0.927	0.525
Risk	1.000	1.000	1.000	1.000

Based on the results obtained, factors relating to personal characteristics of the policyholder and driver(s) have higher impacts than the car and its usage. This might be the main reason for considering human factors when calculating the premium for automobile insurance in many countries. Driver's behavior has been the concern of many scientific researches and insurance companies in risk classification and prediction in automobile insurance (Bian et al. 2018, Tselentis, Yannis and Vlahogianni 2016, Tselentis, Yannis and Vlahogianni 2017) and many companies are trying to use big data for capturing the required information in this regard (Jukić et al. 2015). Payandeh (2015) and Nemati (2014) and also suggests that the automobile insurance policy be issued for each person rather than the car, to consider the risks imposed by the driver (Payandeh Najafabadi 2015, Nemati 2014).

Among the factors in this group, the type of policy holder (person/legal entity) seems to have the highest impact on the risk and the second and third positions refer to occupation and gender. The highest rank for the type of policy holder can reflect the importance of human characteristics (age, gender, etc.), more than one driver for a car and the accuracy of the owner person in driving, while the negligence of the driver that do not have any interest in the subject matter of insurance. Besides, taking into account the deductibles for each claim payment in the Iranian insurance companies for hull insurance, a legal entity is more willing to follow up the claims, while persons mostly prefer not to report small claims to benefit from future discounts.

In the group of car attributes, the value of the car is the most important factor followed by the car manufacturer country. Considering the coverages in the hull insurance (which are rather in contrast with TPL) and also the fact that for calculating the premium to be paid in hull insurance, the value of the subject matter of insurance is multiplied by a coefficient (which is determined based on the risk), this result seems to be logical.

Finally, in the group of car usage, the area in which the car is driven attracts the highest attention, as more crowded areas or areas prone to natural and man-made disasters increase the risk, whether for driving or parking. Although the mileage of driving by a car is considered another important factor in automobile hull insurance, coverages such as theft in this policy highlight the significance of area in which the car is driven.

5. Conclusion

Risk assessment plays a vital role in determining premium rates in the insurance industry. In this regard, identifying the key factors affecting risk is very crucial. Considering the limitation and inefficiencies that the databases in the Iranian insurance companies have, the need for building a general and effective database is felt. However, building such a database requires time and money. Therefore, up to the time this database is build, the experts' opinions can be trust on for identifying the most important pieces of information to be captured when assessing risks.

In this research crucial factors in the risk of automobile hull insurance policies in Iran is identified based on the experts' opinions using Fuzzy Delphi method. Then, these factors are summarized and checked by PLS method to do CFA. Personal characteristics of the driver and ownership earn the highest importance among the 2 other groups of car specifications and car usage. Although some parts of the data such as traffic offences and mileage driven should be

taken from other platforms, most of the factors identified can be used for designing an efficient proposal form. Using these factors in the ratemakings, provided that they are correctly assessed, can lead insurance companies towards a fair ratemaking.
As a suggestion for future research, these factors can be used for designing intelligent expert systems to evaluate the level of risk for the proposers and determining the initial premium rate in the hull insurance. In the next years, the insurance company can increase or decrease the premium rate based on the bonus-malus system applied in the company. Besides, the main outcome of this research for the insurance companies is that the importance of issuing automobile insurance policies for each driver driving a specific car- rather than issuing policies for each car- in Iran is highlighted.

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